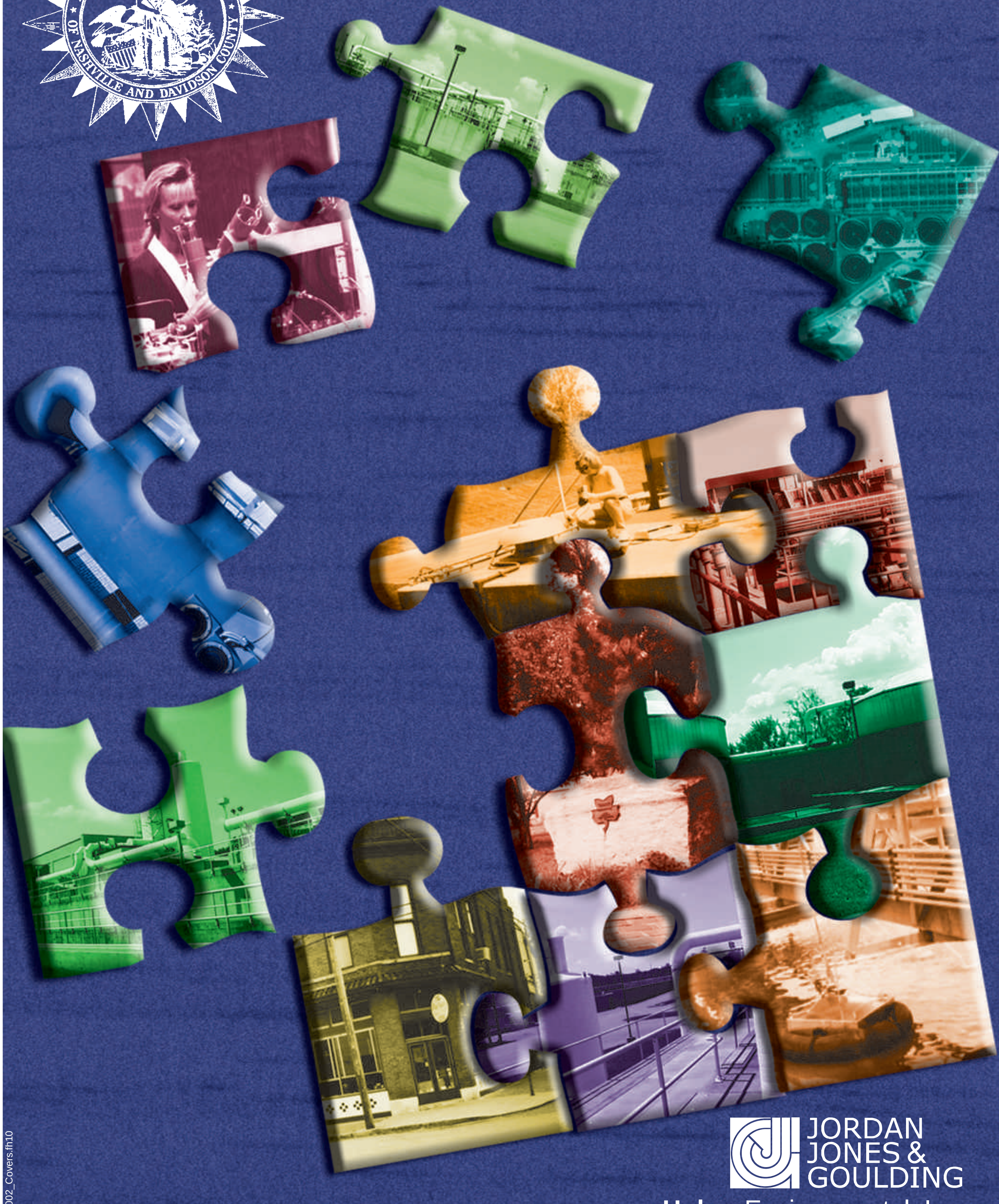
Odor Identification and Control

Dry Creek Wastewater Treatment Plant

Metro Water Services

Metropolitan Government of Nashville and Davidson County

Final Report



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JORDAN JONES & GOULDING

Huber Environmental, Inc.

May 2003

Table of Contents

Section 5 – Requirements for Odor Abatement

Section 6 – Conclusions and Recommendations

Executive Summary

Traditionally, odors emitted from treatment plants have been considered a necessary evil of treating wastewater. Most treatment plants were located in relatively isolated or industrial areas, resulting in little concern for the adjoining property owners. As communities expand, the areas around the wastewater treatment plants have become more populated, and control of odors has become a priority.

Metro Water Services has long been aware that odors from the Dry Creek Wastewater Treatment Plant (WWTP) have been a problem in the surrounding community. Beginning in the early 1990s, Metro Water followed a policy of providing odor control for new construction at any unit process that was considered to be a potential odor source. By the late 1990s, it was apparent that this policy was not resulting in any significant improvement in the odor problem. Metro Water Services determined that in order to be a good neighbor, the commitment would be made to address off-site odors comprehensively – and to approach the problem in an analytical manner to ensure resources are invested efficiently.

In late 2001, the odor evaluation was started. The project team consisting of Jordan Jones & Goulding, Huber Environmental and Metro Water Services, began to evaluate each unit process at the Dry Creek WWTP for odor sources.

The first step of the evaluation was to conduct public meetings to inform citizens about the study procedure and objectives. In addition, a focus group consisting of several residents of the area impacted by the odor problem was established. The focus group was informed about the details of the study throughout the process and had the opportunity to provide input where appropriate.

The next step of the evaluation was to identify all potential odors sources. Each of these sources was then sampled. Point sources (fans, pipes and vent stacks) were sampled by pumping the odorous air directly into a special sampling bag. Area sources (open tanks) were sampled by floating a specially designed hood on the water surface and pumping the odorous air into the sample bag. The sample bags were then shipped overnight to Atlanta for sensory analysis.

Odor is a threshold science. Every odor has a threshold concentration, which is the concentration at which the odor can barely be detected. By determining how many dilutions of fresh air are needed to reduce the concentration of an odor to the threshold concentration, the relative strength of the odor can be determined. This relative strength is expressed as the dilution to threshold ratio (D/T). A panel of people who have been evaluated to determine their sensitivity to odors was used to evaluate the odor samples. For each sample, the relative strength of the odor (D/T) was determined as well as the odor's tendency to linger in the environment.

For each odor source, an exhaust rate was also determined. The exhaust rate is the volume of odor released. When the exhaust rate is multiplied by the D/T, which is an odor concentration, the result is the emission rate, which is the mass of odor generated by the source per unit of time.

The odor emission rates were used in a computer model to determine how far from the treatment plant each odor source would transport. The transport distances were then used to rank each odor source, since the odors that transport the farthest from the treatment plant must be controlled first.

The objective of the project was to prevent any odor source from crossing the property line of the facility. Any odor source that exceeded the objective was included in recommendations for control, and the amount of odor reduction required for each source to meet the property line objective was determined. The odor sources recommended for control in priority order are shown in Table ES-1.

From the odor reduction requirements, a list of possible alternatives was developed. This list included the following types of control alternatives:

- Housekeeping changes – improvements in housekeeping that can result in odor reduction. These items can include more frequent wash down, removal of floating objects from basins, and other similar items.

Table ES-1
Odor Sources – Dry Creek WWTP

Odor Source	Control Method
Equalization Basins	Process change
Primary Clarifier – Weir	Structural – cover and treat
Total Aeration	Process change
Primary Influent Channel	Structural – cover and treat
Head Works Scrubber Exhaust	Structural – previously covered, change treatment technology
Primary Effluent Channel	Structural – cover and treat
Solids Dewatering Scrubber Exhaust	Structural – previously covered, change treatment technology
Dry Creek Pumping Station	Structural – previously covered, change treatment technology

- Process changes – changes in the way that the treatment plant is operated. These types of changes can include taking basins out of service, increasing aeration or adding chemicals
- Structural changes – improvements that require construction, such as covering basins and treating the captured odors.

Many alternatives are available for odor treatment, but only two are practical for treating large volumes of air. The two alternatives are packed bed scrubbers and bio-filters. Packed bed scrubbers remove odors by chemical treatment. They are generally less expensive to construct, but more expensive to operate because of the chemical costs. Bio-filters use bacteria to remove odors. Because bio-filters use a naturally occurring process, the operating costs are low, but they are more expensive to build.

The following process changes are recommended for the Dry Creek WWTP:

- Equalization Basins – In conjunction with a separate hydraulic study, a plan is being implemented to minimize the use of these basins. During large rainfall events when the basins must be used, drain them as quickly as possible. Also, either aerate the entire time the basins are in operation or eliminate aeration.
- Aeration Basins – Maintain dissolved oxygen concentration above 1 mg/L to prevent anoxic conditions.

Areas recommended for structural control of odors include:

- Dewatering Building and Solids Storage Tanks
- Head Works
- Primary Clarifier Influent Channel
- Primary Clarifier Weir Area

Evaluation of the alternatives for structural odor control used net present value (NPV) so that the impact of operating cost was included in the evaluation. NPV is the sum of the construction, or capital, cost of the alternative plus the amount of money that would be to fund operation and maintenance of the alternative for the next 20 years. Table ES-2 lists the scrubber alternative and the bio-filter alternative for the liquid and solids trains that are the most cost effective and allow the greatest ease of operation and their NPV.

Based on the analysis of the alternatives, one bio-filter to treat all of the odor sources from the liquid treatment processes and one bio-filter to treat all of the odor sources from the solids treatment processes are recommended. This alternative has the added benefit of being the most environmentally responsible alternative because a naturally occurring process will be used to reduce odors.

The total estimated capital cost for the recommended alternative is $4,498,000 and the total net present value is $6,323,140.

Table ES-2
Net Present Value Comparison

Description	Alt.	Capital Cost $	Operating Cost $/year	Net Present Value $
Liquid Train				
Two wet scrubbers for the liquid train	1 + 3	2,158,000	81,400	3,172,244
One bio-filter for the liquid train	7	2,712,000	48,200	3,312,572
Solids Train				
Packed bed scrubber for the solids train	5	1,087,000	327,000	5,161,420
Bio-filter for the solids train	6	1,786,000	98,280	3,010,568

Section 1
Introduction

The Dry Creek Wastewater Treatment Plant (WWTP), owned and operated by Metro Water Services serving Nashville – Davidson County, treats primarily domestic wastewater from various communities located in the Northeast Nashville metropolitan area. The facility is permitted under the National Pollutant Discharge Elimination System (NPDES) by the State of Tennessee.

1.1 - Facility Location and Description

The WWTP is located on Edenwold Drive, near the intersection of Gallatin Road and Myatt Drive in Goodlettsville. The facility is bounded on the north by Edenwold Road and CSX Railroad, on the east by the Cumberland River, on the south by Dry Creek and on the west by Myatt Drive.

The current rated capacity is 24 million gallons per day (MGD).

The Dry Creek WWTP incorporates many unit processes for the purpose of treating wastewater. The facility description can be separated into discussions for the liquid train and solids train. In order to help define some of the terminology that will be used in subsequent sections of this report, the individual unit processes, following the flow path of the wastewater, are discussed as follows:

- <u>Liquid Train</u> - The group of processes treating the wastewater from the point that it enters the facility to the point where it is discharged is called the "liquid train."
- <u>Solids Train</u> - During the treatment process, solids are removed from the wastewater. These solids are further treated in the "solids train."

1.1.1 - Liquid Train

<u>Incoming Wastewater</u> – The wastewater enters the facility via two systems. Wastewater from communities to the north (White House, Ridgetop, Goodlettsville, Hendersonville, Millersville) as well as that from Old Hickory is pumped directly to the headworks. The remaining wastewater enters the facility via an interceptor sewer that flows to the Dry Creek Pumping Station, located on site. This pumping station then pumps the wastewater to the headworks. Flows may be diverted to an on-site equalization basin during intense rainfall events.

Some of the communities pumping wastewater to the WWTP add chemicals to the wastewater in an attempt to minimize odors both along the route of the transmission pipelines and at the WWTP.

Figure 1.1
Dry Creek WWTP Location Map

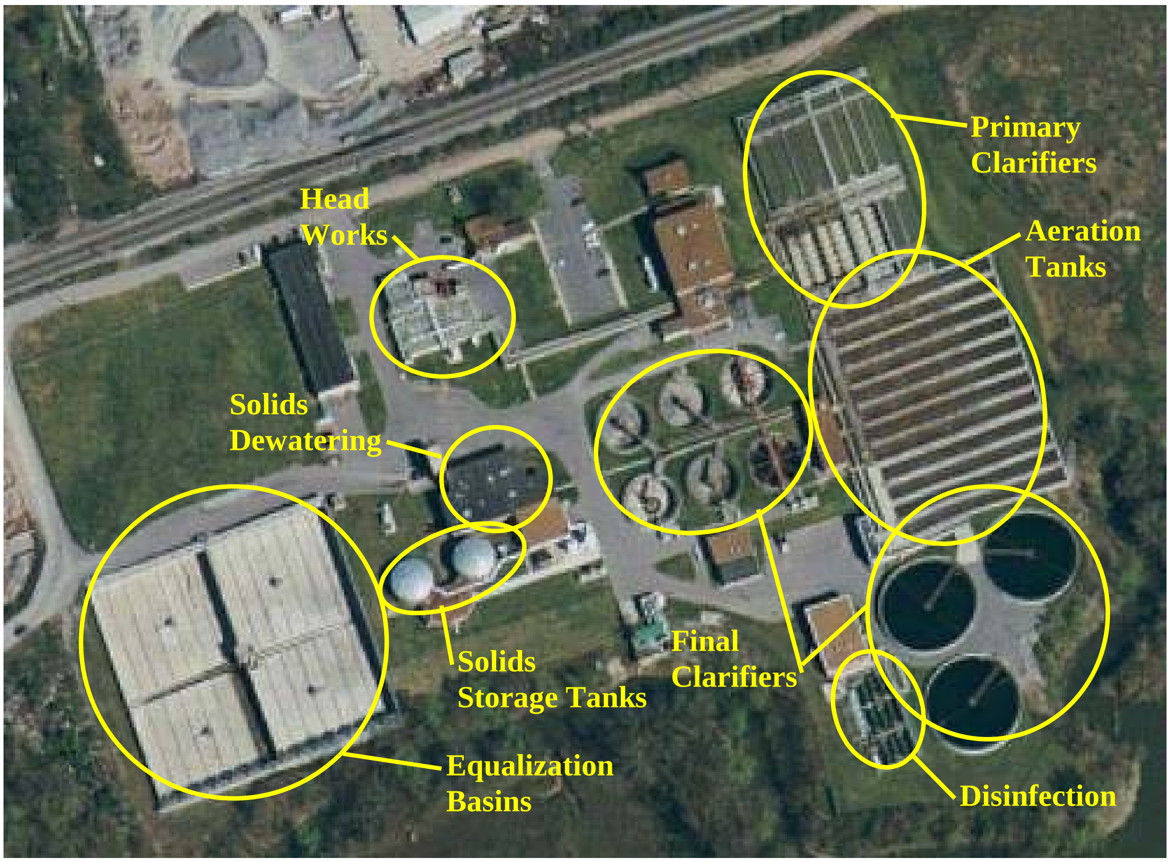

Figure 1.2

Dry Creek Flow Site Plan

Dry Creek Pumping Station – The pumping station has an enclosed wet well (the tank where wastewater enters the pumping station). The air from the wet well is exhausted to an odor control scrubber. Because this pumping station is fed by gravity sewers and aerobic conditions normally occur, the scrubber is not normally operated. At the time of this investigation, the odor control scrubber was not in use.

Equalization Basins – During periods of wet weather, more wastewater enters the WWTP than can be properly treated. During these periods, the wastewater is sent to an equalization basin where it is stored prior to being pumped to the headworks. The equalization basins incorporate mechanical aeration, which is started after the water in the basins reaches a defined level.

When the flow rate into the WWTP decreases, the basins are emptied and cleaned.

The equalization basins are open to the atmosphere.

Headworks - The headworks is the first major treatment process at the WWTP. Unit processes associated with the headworks are:

- Screening - The wastewater is screened in the head works via screens in order to remove any debris that may have entered the sewer system. The screenings that are removed are disposed in a screenings bin. The screens are enclosed.
- Grit Removal - In addition to screening, grit is removed from the wastewater. Grit is heavy solid material such as sand and gravel. The grit removal is accomplished in aerated grit chambers. As in the case of the screenings, the grit that is removed from the wastewater is disposed in grit bins and then disposed off site. Both screening and grit removal are performed to protect wastewater treatment equipment further downstream in the liquid train. The grit chambers are covered and the air within the enclosures is vented to a single stage mist odor scrubber (headworks scrubber - see later discussion).

Headworks Scrubber – Various portions of the headworks are covered and the foul air is exhausted to a single stage wet (mist) scrubber (see Section 5.5.1.5 for description of mist scrubbers). The purpose of the scrubber is to treat the foul air prior to being exhausted to the atmosphere.

Primary Influent Channel – The primary influent channel conveys the wastewater from the grit chambers to the primary clarifiers. This channel is quite long and incorporates aeration in order to maintain solids in suspension. The channel is open to the atmosphere.

Primary Clarifiers – The primary clarifiers are rectangular basins used to settle solids from the wastewater. The basin can be divided into two portions:

- Quiescent Zone – As this would suggest, this zone, which comprises the majority of the area of the tanks, is where the settling occurs.
- Weir Area – At the end of the tank, the wastewater flows over weirs located on the clarifier surface. This area has more turbulence than the quiescent zone.

Solids removed from the primary clarifiers are pumped to the solids storage tank.

The basins are open to the atmosphere.

<u>Primary Effluent Channel</u> – This channel conveys the wastewater from the primary clarifiers to the aeration tanks.

<u>Aeration Tanks</u> - The aeration tanks are part of the biological treatment process. Bacteria are grown in the aeration tanks for the purpose of removing the dissolved organics in the wastewater. Since the bacteria require oxygen (aerobic process), air is added to the basins via diffusers located on the bottom of tanks.

Return Activated Sludge (RAS) is also pumped to the inlet of the aeration tanks. The RAS recycles bacteria from the final clarifiers back into the aeration basins.

As in the case of the primary clarifiers, these tanks are open to the atmosphere.

<u>Mixed Liquor Channel</u> – This channel conveys the mixture of wastewater and bacteria (mixed liquor) from the aeration tanks to the final clarifiers.

This channel is open to the atmosphere.

<u>Final Clarifiers</u> - The wastewater leaving the aeration tanks contain a high concentration of solids. Much of these solids are the bacteria that were grown in the aeration tanks. The final clarifiers act to remove the bacteria via settling.

Whereas the primary clarifiers were rectangular, the final clarifiers are circular. The quiescent zone is located in the center of the tank and the weir area is around the periphery of the tank.

Most of the solids that settle in the final clarifiers are recycled to the aeration basins as RAS. Because the bacteria in the aeration basins are consuming organic material, they are growing and reproducing. In order to keep the bacterial population in balance with the amount of food available, a certain amount of bacteria must be removed from the system on a regular basis. The portion of the solids that are removed from the system is called waste activated sludge (WAS). The WAS is pumped to a solids storage tank.

The final clarifiers are also open to the atmosphere.

The aeration tanks and final clarifiers comprise the secondary treatment portion of the WWTP. The wastewater has been substantially treated by this point.

Disinfection - The final process in the liquid train is disinfection. Chlorine is added to the treated wastewater to kill any residual bacteria that remains in the wastewater. After disinfection, the chlorine is removed from the wastewater prior to the wastewater being discharged.

1.1.2 - Solids Train

There are fewer processes in the solids train, but they are just as important. The solids originate from both the primary and final clarifiers. The solids from these clarifiers are pumped to the solids storage tanks.

Solids Storage Tanks – These covered tanks store the solids prior to being further processed. Although some air is fed into the tanks in order to provide mixing, the air system was not designed to provide sufficient air to keep the contents of the tanks aerobic. The air within the storage tanks is exhausted to the solids dewatering scrubbers (see later discussion).

Solids stored in the solids storage tanks are pumped to the dewatering building for solids dewatering.

Solids Dewatering – The solids from the primary and final clarifiers are mixed together and dewatered within the solids dewatering building via belt filter presses. Chemicals are added to the solids prior to dewatering to aid in the dewatering process.

In addition to chemicals added to aid in dewatering, an oxidizing chemical is also added for the purpose of minimizing odors within the dewatering building.

The dewatered solids are conveyed via a conveyor to a truck located outside of the dewatering building. Air from within the building is also exhausted to the solids dewatering scrubbers.

Solids Dewatering Scrubbers – The system treating the foul air from the solids storage tanks and dewatering building is a 2-stage mist wet scrubbing system (see later discussion).

Future Construction – Presently there are plans to convert the two holding tanks to digesters and construct a third digester. This system would take the place of the existing solids storage tanks.

1.2 – Objectives

In August of 2001, a study was initiated at the WWTP to determine the source(s) of the odors being emitted to the neighboring areas and to determine alternatives for odor abatement. The objectives of this study were to:

1. Determine the specific source(s) of odors that could be impacting the surrounding neighborhood.
2. Determine the degree of removal necessary for each problem source to minimize or eliminate the odors leaving the property.

3. Evaluate alternatives for odor abatement for each source.
4. Evaluate the impact of the proposed improvements on odor emissions.

This report includes the following:

1. Discussion of the methods used for determining the sources of odors.
2. Interpretation of the data.
3. Problem odor source definition.
4. Requirements for odor abatement.
5. Alternatives for odor abatement.
6. Conclusions and recommendations.

1.3 - Odor Study Approach

1.3.1 - Odors

Odors can occur from waste treatment facilities due to many factors:

1. Odor Producing Pollutant Development in the Wastewater - Wastewater that is discharged from residents, commercial, business and industry will have odor causing constituents. The type of odor causing compounds will vary depending on the source. Odorous compounds can be volatile or semi-volatile organics in addition to sulfur and nitrogen based compounds.
2. Conditions in the Incoming Sewers - All wastewater has the potential for odor production. The degree of odor production is dependent on conditions that exist in the sewers. In sewers that have a "slow" rate of flow, the wastewater has the potential to become anaerobic (no or very low oxygen). This condition occurs especially during warm summer months. Sulfur compounds, typically in the form of sulfates (SO_4), are reduced under anaerobic conditions. This reduction causes the formation of dissolved sulfides. Dependent on the chemistry of the wastewater, a portion of the dissolved sulfides will be in the form of hydrogen sulfide (H_2S). The H_2S in the liquid phase remains in equilibrium with the H_2S in the atmosphere above the liquid surface. The amount of H_2S released will be dependent on the atmospheric pressure and other factors occurring at the time. H_2S has a very low odor threshold value (see later explanation) and, therefore, can be a significant odorant.
3. Waste Treatment Processes - In addition to the types of materials in the incoming wastewater and the conditions occurring in the sewers, the waste treatment processes themselves can produce odors. This is valid for both processes associated with the liquid and with the solid trains. Odors can be produced through the addition of chemicals to the liquid train as well as by specific unit processes, such as sludge storage and dewatering.

Due to the number of possible causes for odor production at the WWTP, there are many odor-causing compounds that could exist. This possibility accentuates the problem of "locating" a specific source of odor generation. The measurement of only one pollutant (typically H_2S) can lead to invalid conclusions when studying odor problems.

The occurrence of an odor "problem" involves many steps:

1. Odor Source - There needs to be an odor source. In a treatment facility such as the Dry Creek WWTP, there are many potential sources of odors from both the liquid and solid trains.
2. Odor Release - Although potential odor sources may exist, if that odor is not released to the atmosphere, the odor cannot become a problem. Many of the unit processes described above have the potential for off-gas release. These release points can be:
    - Tanks and channels
    - Aerated tanks
    - Static vents
    - Fan exhausts
3. Odor Transport - Although there may be an odor source and the possibility for that odor to be released, the odor needs to be transported off-site to cause a possible odor problem. This odor transport is totally dependent on meteorological (weather) conditions.
4. Presence of a "Receptor" - A "receptor" is defined as a human nose. Without the presence of a receptor, even though the odor has been released and transported, no odor problem would exist. Historically, when treatment facilities were constructed away from residential and/or urban development, odor problems did not occur, simply because no receptors were present to become aggravated by the problem. As urban areas became more densely populated, more receptors were present and, therefore, the odor problems began to occur.

It has been assumed in this study that all of the above steps have to be present for an odor problem to occur. This is an important assumption in that an odor at the WWTP that is not transported to a receptor is not considered an odor problem.

1.3.2 - Study Approach

The approach taken during the odor study included the following steps. In many cases the results of a preceding step dictated the action of the subsequent step. In general however, the following approach was taken:

1. Identification of All Potential Sources - The WWTP was toured and plans and specifications were reviewed to determine all potential odor release points.

2. Sampling of All Release Points - All potential sources identified in Step 1 were sampled.
3. Evaluation of Samples - The samples collected in Step 2 were evaluated by two methods:
   - Sensory evaluation, and
   - Specific pollutant evaluation
4. Data Interpretation and Ranking - All data from Step 3 was interpreted and ranked in order of most significant to least significant.
5. Screen Modeling – The data determined most significant from Step 4 was computer modeled using an EPA approved air dispersion model. The results of this modeling indicated the potential for a specific odor to travel off-site.
6. Establishment of Objectives - Objectives were established which dictated the degree of removal required for each problem source.
7. Determination of Required Percent Removals - Based on the objectives established in Step 6, and the screen modeling results (Step 5), the percent removals were determined for each problem source.
8. Alternatives Evaluation – Alternatives were reviewed which would meet the objectives and associated required percent removals.
9. Conclusions and Recommendations - Based on the work performed in the steps above, conclusions were reached as to the sources of odors that are or could reach receptors and the available alternatives for odor abatement.

The format of this report follows the steps taken in the odor study. Presented herein is the following:

- The methodology used during the investigation
- The basic data from sample analyses
- Data interpretation
- Impacts of odors
- Alternatives for odor abatement
- Conclusions and recommendations

1.4 – Focus Group

A focus group was formed comprised of residents of nearby neighborhoods. The group met three times in the evenings.

The objectives of the focus group were as follows:

- Monitor the process and schedule.
- Provide input in establishing an abatement objective.
- Provide advice related to abatement strategies.

In addition to the above, members of the focus group maintained odor occurrence logs. These logs were used to triangulate odor sources.

The agendas for the meetings and those taking part in the focus group are included in the appendices of this report.

Section 2
Initial Facility Investigations

2.1 - Facility Inspection

In August of 2001, the Dry Creek WWTP was inspected in order to become familiar with the facility and to identify all potential odor sources and release points from the unit processes within the facility. Observations made during the inspection were the basis for further investigation of odor sources. Table 2.1 presents all of the potential release points identified during the inspection.

Table 2.1
Odor Release Points
Dry Creek WWTP

Unit Process	Sub Area	Comments
Dry Creek Pumping Station	Scrubber Exhaust	Not Operating – Vent Discharge
Equalization Basin	-	With and Without Aeration
Headworks	Headworks Scrubber	Inlet and Outlet
Primary Clarifiers	Influent Channel	-
	Inlet Area	-
	Quiescent Zone	-
	Weir Area	-
	Effluent Channel	-
Aeration Tanks	Influent Area	-
	Middle Area	-
	Effluent Area	-
	Effluent Channel	-
Final Clarifiers	Quiescent Area	-
	Weir Area	-
Solids Processing	Air From Storage Tanks	-
	Air From Dewatering Building	-
	Solids Dewatering Scrubber	Inlet and Outlet

3.1 – Sampling Locations and Sample Types

Samples were collected from all potential odor release points shown in Table 2.1 beginning in August 2001. Additional re-sampling occurred in November of 2001 and February of 2002.

There are three different types of sources:

- Point source discharges - Point sources are sampled by placing the suction line of a peristaltic pump directly into the discharge of the vent or exhaust.
- Area sources (no air addition) - These are sources such as open tanks and channels that do not have aeration or other forms of air addition. Sampling of area sources is accomplished by the use of an equilibrium chamber, called a floating emission sampler (FES). When floated on the water surface, the FES forms a trapped air space with a surface area of approximately three (3) square meters. An airflow rate per unit area is established by the peristaltic pump's pumping rate. The airflow rate used in setting the peristaltic pump was determined by the expected evaporation or exhaust rate.
- Area sources (with air addition) - These sources are similar to the area sources described above except that the tank has air addition. The only difference in sampling these sources versus sources with no air addition is the airflow rate of the peristaltic pump. An attempt is made to match the airflow rate of the pump with the airflow rate entering the tank.

Table 3.1 indicates the sampling locations for the source locations shown in Table 2.1. In addition, the sample date and type of sample are provided.

3.2 - Sampling Procedures

For all of the above locations, air samples were collected in Tedlar bags through Tygon tubing. Tedlar sampling bags were used due to their resistance to retention of odorous compounds. Each bag was pre-conditioned with a sample of the off-gas stream to be evaluated and then evacuated before starting the sampling. Bags were filled to approximately 75 to 80% of capacity.

For all of the sources, equipment was rinsed and cleaned between each sampling. ASTM procedures for air sampling were followed during the sample collection activities. Samples were presented for sensory evaluation within 24 hours after collection. In addition to samples collected as indicated above, field measurements of hydrogen sulfide (H_2S), mercaptans and ammonia were also taken. These measurements were taken concurrently with the odor sample collection. A Jerome 631-X gold film auto-ranging

Table 3.1
Sample Locations
Dry Creek WWTP

Location	Sample #	Date	Sample Type
Dry Creek Pumping Station	24	10/08/01	P
Equalization Basin – 14 Foot Depth	23	10/08/01	A
Equalization Basin – 20 Foot Depth	11	8/06/01	A
Headworks Scrubber Inlet	19	8/20/01	P
Headworks Scrubber Exhaust	20	8/20/01	P
Primary Influent Channel	1	8/20/01	V
Primary Clarifier – Influent	2	8/16/01	A
Primary Clarifier – Quiescent	3	8/16/01	A
Primary Clarifier – Weir Area	4 32	8/16/01 2/25/02	A A
Primary Effluent Channel	5	8/20/01	A
Aeration Basin – Inlet	6 33	8/06/01 2/25/02	V V
Aeration Basin – Midpoint	7 34	8/06/01 2/25/02	V V
Aeration Basin – End	8 35	8/06/01 2/25/02	V V
Mixed Liquor Channel	9	8/06/01	A
Final Clarifier – Quiescent Zone	10	8/20/01	A
Dewatered Solids w/ Permanganate	12	8/22/01	A
Dewatered Solids w/o Permanganate	13	8/22/01	A
Dewatering Building w/ Permanganate	14	8/22/01	P
Dewatering Building w/o Permanganate	15	8/22/01	P
Solids Storage Tank Exhaust	27	11/26/01	P
Dewatering Building Exhaust	26	11/26/01	P
Solids Dewatering Scrubber – Inlet	16 28	8/22/01 11/26/01	P P
Solids Dewatering Scrubber – 1st Stage	17	8/22/01	P
Solids Dewatering Scrubber – Exhaust	18 30	8/16/01 11/26/01	P P

H_2S analyzer was used to measure the hydrogen sulfide and Draeger tubes were used to measure mercaptans and ammonia.

3.3 - Sensory Evaluation

3.3.1 - Odor Panel Selection

The air in the Tedlar sample bags was submitted to an odor panel, located in Atlanta, Georgia, for sensory evaluation. Ten (10) individuals served on the odor panel. All panelists had been previously screened to determine their sensitivity to various odor thresholds.

3.3.2 - Sensory Analysis Procedures

3.3.2.1 - Odor Concentration

The forced choice triangle principle was used to determine the odor threshold of samples collected at the WWTP. A dynamic olfactometer served as the device to supply six serial dilutions of

Figure 3.1
Dry Creek Sample Points

odor sample to the panelist. Each panelist was presented three samples (triangle principle) at each dilution level and was asked to select the sniffing port that contained the odor. Two of the ports discharged non-odorous air. The panelist was asked to make a judgment (forced choice principle) as to which port delivered the odor. If no odor was distinguished, the panelist was instructed to make a guess.

The forced choice triangle procedure was used to eliminate the problem of handling false-positive data generated by other techniques that involve selection based on odor/no odor responses. Each panelist progressed from the port containing the most diluted sample toward those with higher concentrations until all six dilutions were administered. Response at each sample port was recorded. Data was later interpreted by a statistical procedure to determine the D/T value for each sample.

D/T is defined as the effective dosage at the 50% level; that is, the dilution at which half of the panelists would detect the odor. For example, a D/T value of 100 means that the odorous air must be diluted 100 fold before 50% of the panel members would not detect the odor. A D/T value of 1 is defined as the detectable threshold or a point at which a person with average sensitivity detects the presence of an odor in an otherwise clean environment. The D/T is synonymous with ED_{50} and the term "odor unit." In other words, an odor unit of 1 represents the median detectable threshold level. Odor levels less than 1 are below the median detectable threshold level. Odor levels less than 0.1 odor units are below <u>any</u> detectable level.

Odor concentration determinations were conducted in accordance with ASTM Standard of Practice E679.91, Determination of Odor and Taste Thresholds by a Forced-Choice Ascending Concentration Series of Limits.

3.3.2.2 - Odor Intensity

Butanol intensity measurements were also performed to characterize the intensity of the odor samples. Odor threshold alone does not provide an indication of intensity at varying dilutions. Butanol intensity values provide a comparison of the strength of a specific odor to the strength of the odor emitted from butanol alcohol at various concentrations.

Odorants are typically found to change in intensity according to the power relationship, Intensity (S) = KC^n where K and n are coefficients dependent on the odorant and C, the concentration. For butanol, the value for n is 0.66. By defining an odor intensity of 250 parts per million of butanol as 10, an odor intensity scale can be developed where K = 0.261. This reference scale is used to define the intensity of odors.

A dynamic-dilution binary scale olfactometer was used to determine the characteristic of butanol intensity. This device has eight (8) glass sniffing ports attached to a free spinning wheel. Each port was supplied with a successively higher concentration of butanol to establish a range of odor intensities for comparison with odor samples. Panelists were asked to judge the intensity of an undiluted odor sample with the butanol wheel to determine which dilution was most similar to the actual sample. Responses from each panelist were recorded and used to calculate the equivalent butanol intensity value. Odors with the butanol intensity value less than 1.0 ppm are generally considered weak and approach threshold intensity. The actual threshold for butanol is 0.3 ppm.

3.3.2.3 - Odor Persistence

Persistency is a term used to indicate the pervasity or the "lingering" effect of an odor. Persistency is determined by measuring both the concentration of the odor and the intensity and then comparing the slope of the comparison. The perceived intensity of an odor will change in relation to its concentration. However, the rate of change in intensity versus concentration is not the same for all odors. More persistent odors have a higher perceived intensity at lower concentrations; therefore they appear to "hang around" longer than less persistent odors.

The persistency of an odor is represented as a "dose-response" function that is determined from intensity measurements of an odor at full strength and at other dilutions above the threshold level. The plotted values, as logarithms, of the intensity and dilution ratio establish the dose -response function. The slope defines the persistency.

3.4 - Odor Sampling Results

Table 3.2 presents the primary data concluded by the odor panels in addition to hydrogen sulfide concentrations collected in the field during the sampling. For a more detailed data presentation, refer to the appendix of this report.

In all cases, the data regression was excellent. In some cases, the regression becomes difficult since as the D/T and the intensity of odors become low, it is sometimes difficult to differentiate the odor level at varying dilutions.

Further interpretation and discussion of the data will be provided in Section 4 of this report.

Table 3.2
Base Analytical Results
Dry Creek WWTP

Location	Sample #	D/T	H_2S (ppm(v))
Dry Creek Pumping Station	21	191	0.57
Equalization Basin – 14 Foot Depth	20	584	0.26
Equalization Basin – 20 Foot Depth	11	840	0.13
Headworks Scrubber Exhaust	17	550	0.00
Primary Influent Channel	1	289	1.3
Primary Clarifier – Influent	2	217	0.22
Primary Clarifier – Quiescent	3	128	0.4
Primary Clarifier – Weir Area	4 25	1,362 50	6.60 0.00
Primary Effluent Channel	5	44	0.15
Aeration Basin – Inlet	6 26	87 329	0.13 0.00
Aeration Basin – Midpoint	7 27	26 133	0.007 0.00
Aeration Basin – End	8 28	14 113	0.002 0.00
Mixed Liquor Channel	9	14	0.003
Final Clarifier – Quiescent Zone	10	12	0.014
Dewatered Solids w/ Permanganate	12	457	2.2
Dewatered Solids w/o Permanganate	13	327	3.0
Dewatering Building w/ Permanganate	14	249	7.4
Dewatering Building w/o Permanganate	15	618	17.0
Solids Dewatering Scrubber – Exhaust	16 23	325 565	6.6 8.0

Section 4
Impact of Odor Emissions

4.1 - Odor Emission Rates

Sensory data alone cannot be used to conclude whether a specific odor source can become an odor problem. Although a specific release point may have a high odor concentration and/or intensity, if that source has a low air release rate, it may not be a problem. The air release rate for area sources will depend on the surface area of the particular unit process. The air release rate for point sources will be the actual airflow rate being discharged. The air release rate for area sources with air addition will be dependent on both the air flow rate and the surface area.

Sensory data coupled with calculations of volumetric emission rates were used to estimate the mass of odor emissions in terms of odor concentration and intensity. Point source odor emission rates were quantified by multiplying both odor concentrations (D/T) and equivalent butanol intensity concentrations by the estimated volumetric rate of the exhaust stream. Area source odor emission rates were determined from estimates of odor release per unit area multiplied by the total surface area of each source, multiplied by the odor concentration and/or equivalent intensity. The estimated release rate for quiescent sources was calculated assuming a PAN evaporation rate at a temperature of 90^{o} F. For turbulent sources such as splitter boxes and weirs, turbulence factors were used. The exhaust rate for area sources with air addition was the air rate being introduced into the process.

Mass emissions from the various sources identified at the WWTP were used as the basis for evaluation of atmospheric dispersion and impact on the surrounding areas.

Table 4.1 tabulates the exhaust and odor emission rates calculated for all unit processes that were sampled. The odor emission rate (OER) is based on the D/T of the sample and the exhaust rate. The OER is, therefore, the product of the D/T times the exhaust rate reported in D/T – CFM x 10^{6}.

4.2 - Screening of Odor Emissions

Table 4.2 ranks the sources based on D/T and odor emission rates.

4.3 - Meteorological Factors

The most significant factors in air transport are the local meteorological conditions. Such local weather conditions play a key role in the overall impact of odor emissions on the area surrounding the source. The most significant factors governing odor dispersion are:

Table 4.1
Odor Exhaust Rates and Emission Rates
Dry Creek WWTP

Location	Sample #	Exhaust Rate Ft^3/Min	Odor Emission Rate D/T x ft^3/min x 10^6
Dry Creek Pumping Station	21	5,000	0.955
Equalization Basin – 14 Foot Depth	20	8,932	5.22
Equalization Basin – 20 Foot Depth	11	8,932	7.50
Headworks Scrubber Exhaust	17	3,000	1.65
Primary Influent Channel	1	2,500	0.723
Primary Clarifier – Influent	2	575	0.125
Primary Clarifier – Quiescent	3	575	0.074
Primary Clarifier – Weir Area	4	2,300	3.13
	25	2,300	0.115
Primary Effluent Channel	5	3,000	0.132
Aeration Basin – Inlet	6	10,667	0.928
	26	10,667	3.51
Aeration Basin – Midpoint	7	10,667	0.277
	27	10,667	1.42
Aeration Basin – End	8	10,667	0.149
	28	10,667	1.21
Mixed Liquor Channel	9	2,500	0.035
Final Clarifier – Quiescent Zone	10	1,719	0.021
Solids Dewatering Scrubber – Exhaust	16	30,000	9.75
	23	30,000	16.95

Table 4.2
Source Ranking (Descending Order)
Dry Creek WWTP

D/T	Odor Emission Rate
Primary Clarifier - Weir	Dewatering Scrubber Exhaust
Equalization Basin	Equalization Basin
Dewatering Scrubber Exhaust	Aeration Basin – Influent
Headworks Scrubber Exhaust	Primary Clarifier – Weir
Aeration Basin – Influent	Headworks Scrubber – Exhaust
Primary Influent Channel	Aeration Basin – Midpoint
Primary Clarifier – Influent	Aeration Basin – End
Dry Creek Pumping Station	Dry Creek Pumping Station
Aeration Basin - Midpoint	Primary Influent Channel
Primary Clarifier – Quiescent	Primary Effluent Channel
Aeration Basin – End	Primary Clarifier – Influent
Primary Effluent Channel	Primary Effluent Channel
Mixed Liquor Channel	Primary Clarifier – Quiescent
Final Clarifier - Quiescent	Mixed Liquor Channel

- Atmospheric stability
- Wind speed, and
- Wind direction

4.3.1 - Atmospheric Stability

Atmospheric stability refers to the degree of vertical turbulence present. The greater the turbulence, the greater is the dispersion. Unstable air provides more turbulence, whereas stable air provides less turbulence. As would be expected, odor will travel greater distances during stable air conditions (least amount of turbulence). Therefore, the worst case for odor transport, when considering stability, will be during very stable air conditions.

Atmospheric stability is ranked in six categories, A through F or 1 through 6 depending on the reference. Stability Class A (or Class 1) refers to the most unstable air, and therefore, the most turbulent conditions occurring at the time. Stability Class F (or Class 6) refers to the most stable condition. Therefore, for odor transport, Class F would provide the worst-case condition.

4.3.2 - Wind Speed

Wind speed also determines the rate of dilution, with higher wind speeds creating more dispersion and dilution than lower wind speeds. Wind speed can be routinely measured as low as one meter per second. The condition, when the wind speed is less than one meter per second, is considered “calm”. For reference purposes, 1 meter per second is approximately equivalent to 2.23 miles per hour.

When combining the impacts of atmospheric stability with wind speed, the worst case for odor transport is during Class F stability and a wind speed of 1 meter per second.

4.3.3 - Wind Direction

Wind direction determines the direction in which the odorous air will travel. For the initial modeling, wind direction was not considered. Therefore, all results will be considered radial results and not specific to any one wind direction.

4.4 - Dispersion Modeling

Odor impacts on neighboring areas surrounding the WWTP were evaluated by estimating ground level odor concentrations radially around the WWTP. In order to determine the odor concentrations, atmospheric dispersion modeling of odor emissions was performed using the USEPA Screen Model, Version 3.0. This model is based on a standard gaussian model that predicts average atmospheric concentrations at downwind receptors for a minimum time of one hour. The model provides a good indication of average short-term conditions, but does not predict the peak instantaneous occurrences of odor above threshold that can occur even when the mean value for an hour is below the threshold limit. It is known that peak or instantaneous concentrations of odor can occur in “puffs.” The paragraphs that follow will indicate how this problem was managed.

1. Develop Dose - Response Slope - A dose response relationship was developed for each source. The logarithm of the butanol intensity (y-axis) was plotted against the logarithm of the odor concentration (D/T) (x-axis).
2. Select End Point Concentration - Based on the assumptions indicated below, the end point concentration in micrograms per cubic meter was determined from the dose-response curve.
3. Screen Model - The source concentration (grams per second) was inputted into the model along with all other data. Modeling was performed to determine the distance from the source, at various atmospheric stabilities and wind speeds, before reaching the allowable downwind concentration. All distances less than 100 meters were disregarded during this initial modeling.

The following assumptions were used to determine end point concentrations:

1. Average Conditions (Hourly) - For hourly conditions, the actual concentration found in the odor survey was used as the initial concentration. The end point concentration was determined to be that concentration associated with a D/T of 1 corrected by incorporating the slope of the dose – response function. This was selected as a conservative estimate for screening purposes.
2. Peak (Instantaneous) - For peak conditions, the actual concentration found during the odor survey was multiplied by a factor. The point source factor was 3 and the area source factor was 10. These values were selected based on previous plume dispersion studies.

The wind speed considered during the modeling was one meter per second (worst case).

The input data for the modeling is included in the appendices of this report.

4.5 - Results of Odor Modeling

Table 4.3 presents the results of the odor modeling under both hourly and peak conditions at an F stability class and a wind speed of 1 meter/second. The remaining modeling results can be found in the appendices of this report.

For the primary clarifiers and the aeration tanks, the individual areas were totaled and modeled together, i.e. “Total Primaries” and “Total Aeration”.

All distances are in meters. No distances greater than 2,000 meters were modeled.

Odors that transport significant distances are termed Class 1 sources (odors).

Table 4.3
Class 1 Odor Sources
Dry Creek WWTP

Source	Average Transport Distance (Meters)	Peak Transport Distance (Meters)
Equalization Basin	>2,000	>2,000
Total Primaries	>2,000	>2,000
Primary Clarifiers – Weir	>2,000	>2,000
Total Aeration	1620	>2,000
Solids Scrubber Exhaust	650	>2,000
Headworks Scrubber Exhaust	350	1,000
Primary Influent Channel	350-	1,690
Primary Effluent Channel	-	520

4.6 - Calm Wind Conditions

The results presented in the previous section are for conditions when mixing occurs and exclude calm wind conditions (wind speed < 1 meter/sec.). These conditions historically occur in the Nashville less than 10% of the annual hours. Calm wind conditions present the following significant problems:

- During a period of calm wind conditions, odors tend to concentrate in the atmosphere above the source and will move away from the source with no dispersion. Should the concentrated odors move in the vicinity of a receptor, the intensity could be considerably greater than what is predicted by the model.
- During calm wind conditions, the concentrated odor cloud becomes the theoretical source of emissions. Since the concentrated odor cloud can move away from the source, once dispersion begins, the distance from the actual source to the receptor can be decreased from that predicted in the model.

Those sources that would be of concern during calm wind conditions are those with significant odor emission rate (> .5 cfm X 10^6 odor units) and sources with high D/T values. The actual D/T value is subjective, but most would select 100. Calm wind problems occur most often with area type sources. Dispersion from fan discharges, assuming the discharge velocity is sufficiently high, creates self-induced dispersion.

The Dry Creek Pumping Station is the only additional Class 2 source.

The Class 1 sources and the Dry Creek Pumping Station source comprise the list for Class 2 odor sources.

4.7 – Odor Logs

Odor logs were maintained by citizens at five locations. The data from the odor logs was analyzed by a computer program that uses triangulation to identify the potential source for each odor occurrence recorded. The complete program results for "Odor Occurrences" is included in the Appendix of this report.

Prior to presenting the conclusions from the odor logs, the following explanation regarding the program is offered:

1. The program is based on global positioning coordinates (GPS) for both specific unit processes at the treatment facility and the location of the odor receptors. The locations of all unit processes were entered into the program.

   The location of the odor occurrences were:

   - 1903 Spring Branch Road
   - Myatt Drive at bridge
   - 1217 Northgate Business Parkway
   - 2105 East Hill Drive
   - Myatt Drive at Dollar General

2. The meteorological data used in the analysis was from the Nashville Airport (BNA). Therefore, due to the distance from BNA to the Dry Creek WWTP, there may be discrepancies in the actual conditions occurring at the site.

3. "Random" in the program represents "calm wind" conditions. During these periods, no triangulation can be made.

4. Odor transport distances are calculated based on the previous intensity sampling that occurred.

5. In some cases the various unit processes are located close together. Unless there are multiple witnesses to the same odor event and the witnessed locations are far apart, the program is unable to adequately discern the specific source.

The conclusions from the triangulation analysis are as follows:

1. In most cases, the air stability occurring at the time of the event was Class F. This result is consistent with the results from the previous modeling.

2. The sources that were cited with the program were:

   - Equalization basins – Four events
   - Primary clarifiers – One event
   - Primary influent channel – Two events
   - Aeration tanks – One event

Odors have been witnessed near the Wal-Mart located on Gallatin Road north of the treatment plant. At times, it is believed that there are other sources of odors other than those from the Dry Creek facility. Unfortunately, the triangulation exercise was unable to determine their source.

4.8 - Summary and Discussion

4.8.1 – Priority Odor Sources

Sources that are considered problems during low wind conditions are termed "Class 1" sources. Odor sources that are considered problems during calm wind conditions are termed “Class 2” sources. Table 4.4 summarizes both source classes.

Table 4.4
Priority Odor Sources (In order of Priority based on transport distances)
Dry Creek WWTP

Class 1 Sources	Class 2 Sources
Equalization Basins	Class 1 Sources
Total Primaries	Dry Creek Pumping Station
Primary Clarifier – Weir	
Total Aeration	-
Solids Scrubber Exhaust	
Headworks Scrubber Exhaust	-
Primary Influent Channel	-
Primary Effluent Channel	

4.8.2 – Discussion

The following is a discussion of each of the priority odor sources. This discussion is focused on the data and the interpretation of the data.

Table 4.5 presents the relative priority of all significant odor sources based on odor emission rate.

As can be seen from Table 4.5, the most significant odor source, based on odor emission rates, is that from the dewatering scrubber system. However, due to the induced dispersion from the point source, this source transports a lesser distance than other sources. The equalization basins, the primary clarifiers and the aeration tanks are more serious sources during worst-case meteorological conditions.

Table 4.5
Composite Odor Profile
Dry Creek WWTP

Location	OER (D/T x cfm x 10^6	% of Total
Dewatering Scrubber Exhaust	16.95	44.3
Equalization Tank	7.50	19.6
Aeration Basins	6.13	16.0
Primary Clarifiers	4.19	10.9
Headworks Scrubber Exhaust	1.65	4.3
Dry Creek Pumping Station	0.96	2.5
Primary Influent Channel	0.72	1.9
Primary Effluent Channel	0.13	.34
Mixed Liquor Channel	0.04	.10
Final Clarifiers	0.02	.05

4.8.2.1 – Influent Wastewater Characteristics

Although wet chemistry samples were not taken at this facility during this investigation, Metro staff and the staff at Dry Creek routinely measure hydrogen sulfide (H_2S) in the incoming wastewater. At times the H_2S concentration is high, especially from other communities served by this facility. Although the communities are supposed to be adding chemicals (Bioxide®) to minimize odors, it would appear that either an insufficient amount is being added, or that the addition is sporadic.

Controlling H_2S at the influent to major transmission pipelines is important for both odor control and corrosion control. Since the head works will require odor control due to the presence of other odorous compounds and regardless of the concentration of H_2S in the incoming wastewater, a greater addition will be of little benefit to odor control at the Dry Creek WWTP; therefore corrosion control in the pipelines becomes the overriding factor in this case.

Constant and adequate feed of odor and corrosion control agents is strongly recommended.

4.8.2.2 – Equalization Basins

The equalization basins are problem odor sources during wet weather events. The strength of the incoming wastewater during initial periods of a rain event is high. As the event continues, however, the odor potential will decrease due to dilution. Reducing the amount of wastewater to the equalization basins and/or reducing the time the wastewater remains in the basins will significantly reduce the potential for odor emissions.

Aeration is commenced after the level in the basin reaches a specified depth. When the aeration commences, the exhaust rate increases significantly, thereby increasing the mass of odor introduced into the atmosphere.

4.8.2.3 – Headworks

During the investigation, the area under the covers at the grit chambers was smoke tested for leakage. It was found that considerable leakage occurred. Although the amount of fugitive emissions from these leaks is relatively low, they still represent an odor emission source.

The efficiency of the existing head works scrubber was determined during the investigation and reported as follows:

- Inlet D/T – 550
- Exhaust D/T – 380
- Efficiency – 31%

4.8.2.4 – Primary Influent Channel

Due to the length of this channel, it is a significant odor source. As indicated previously, it is not believed that the addition of additional odor and corrosion control chemicals in the sewer system will reduce the odors from this source so as to not require control.

4.8.2.5 – Primary Clarifiers

Based on initial sampling, the majority of odor from the primary clarifiers originates from the weir areas. A second sampling indicated very low odors from the weir area. However, the data from this second sampling is much lower than that found at other similar facilities and is therefore suspect.

4.8.2.6 – Aeration Basins

Repeated sampling indicated that the data for all portions of the aeration basins was much higher than expected. An industrial contribution was considered as the cause for these high odors. However, it has been reported that at times some of the blowers providing air to the aeration basin turn off due to electrical problems. This would cause the dissolved oxygen in the basins to decrease. Due to this decrease, the odor levels could well increase. The low dissolved oxygen periods in the aeration basins should be eliminated.

4.8.2.7 – Primary Effluent Channel

As indicated previously, odors are transported from the primary effluent channel. However, the concentration of odor is much lower than from the other significant sources. No abatement will be considered at this time for this source.

4.8.2.8 – Dewatering Scrubber System

The existing system is a 2-stage, 30,000 cfm mist scrubber system. The efficiency of this system depends on the contact time of the foul air with the chemicals being added. At the time of the initial investigation, only sodium hypochlorite, NaOCl, was being added. It was recommended that sodium hydroxide be added to ensure that the pH of the solution is maintained at or above 10.0 in order to optimize removal rates.

After this change was made, the exhaust from these scrubbers was once again sampled. Little improvement was found.

The efficiency of the dewatering scrubber (solids scrubbers) was found to be as follows:

- Inlet D/T – 639
- Exhaust 1st stage – 962
- Exhaust 2nd stage – 565
- Efficiency – 12%

The low efficiencies found in both the head works scrubber and the dewatering scrubbers are common due to the difficulty in keeping the nozzles located inside the scrubber operating correctly.

Section 5
Requirements for Odor Abatement

5.1 - Abatement Objective

At the present time, there are no federal and/or state requirements or standards for odor control. When Congress and EPA addressed the most recent Clean Air Act Amendments, they had difficulty in determining specific requirements due to the site specific and area specific nature of odors. For this reason, they deferred the problem to states and local governments. Tennessee presently has no standards for odors. Many local governments, including Metropolitan Nashville, have nuisance ordinances that include odors. However, these standards are usually in narrative form rather than numerical. The purpose of most ordinances is to allow third party litigation against an odor producer and not necessarily, provide a clear standard for abatement.

Objectives for solving odor problems can and have been established based on different criteria:

- Economics - Some communities, when having an odor problem, allocate a certain amount of financial resources to a project, prior to understanding the actual cost for abatement. Odor reducing steps are implemented with the hope that the odor will be reduced.
- Frequency of Occurrence at a Specific Receptor - Another method of establishing an objective for odor abatement is to set an agreed upon frequency of odor occurrences at a specific location. This allows for odors to occur, but defines the frequency of occurrence.
- Source Odor Units - A specific standard at the source can be set. The standard would be in terms of a D/T.
- Property Line D/T - This method sets a specific standard at the property line of the facility. During agreed upon weather conditions, this standard is not to be exceeded.

Many municipal and county governments in the United States are establishing specific standards for odor concentration at property lines. Should the State of Tennessee and/or local government establish a standard in the future, it probably will be consistent with what is now occurring at other locations - a property line or boundary standard.

The actual numerical standard varies among localities. The range across the United States appears to be 2 - 15 odor units at the property line.

In the Southeast, a D/T of 5 is becoming prevalent. This objective allows for odors across the property boundary occasionally, but only during the most stable meteorological condition. During normal periods, odors would not be witnessed outside of the facility property boundaries.

Metro Water Services established the following objective: a D/T of 5 at the property boundary during "worst case" meteorological conditions. Therefore, during some periods of time, odors will still be witnessed outside of the property boundaries. However, the frequency of these events will be greatly reduced.

5.2 – Abatement Strategy

Care should be taken when interpreting Table 4.5, which shows the composite odor profile for the Dry Creek WWTP. Odors are not necessarily additive. Odors from different sources are only additive if they result from the same odorant and exist in the same dispersion plume. This is rarely the case with odors from waste treatment facilities. If a less significant odor is addressed before a more significant one, the more significant odor will prevail and the receptor will notice little or no improvement in air quality. Therefore, it is essential to abate the odor source that transports the farthest first, and then abate the lesser sources second.

For the Dry Creek WWTP, the majority of odor events have been occurring from the equalization basins (when in service), the primary clarifiers, the primary influent channel, the aeration tanks and the dewatering and headworks scrubber systems. Therefore, the abatement strategy must be to abate these odors prior to others.

5.3 - Required Percent Removals

Table 5.1 presents the required removal percentages for the problem odor sources. The percent removal is based on the distance to the closest property line. Percent removals are indicated to achieve both an odor objective of 5 and 1 at the property boundary. The percent removals for both average and peak conditions are shown.

Table 5.1
Required Percent Removals For Significant Sources
Dry Creek WWTP

Source	Distance to Property Boundary (Feet)	Average Conditions		Peak Conditions
		D/T = 5	D/T = 1	D/T = 1
Equalization Basin	300	83%	97%	98%
Total Primary Clarifiers	100	52%	90%	99%
Primary Clarifier Weir	100	77%	95%	99%
Total Aeration[1]	300	57%	89%	95%
Solids Scrubber Exhaust	500	0%	47%	56%
Headworks Scrubber Exhaust	200	0%[2]	10%	40%
Primary Influent Channel	200	15%	82%	97%
Primary Effluent Channel	150	0%	0%	83%

[1] Data Based On Second Sampling
[2] This does not indicate the required efficiency of the scrubber, but the incremental efficiency that is required

5.4 – Impact of Planned Expansion

As indicated in previous sections, there is consideration being given to adding anaerobic digestion at this facility. The anaerobic digesters would replace the existing solids storage tanks.

This change should reduce the odor levels going to the existing dewatering scrubber system. However, the nature of the odors will also change. Whereas presently the odors are primarily sulfur based, in the future, nitrogen compounds could also be present.

5.5 – Alternatives for Abatement

The essential elements for successful odor control are:

- Adequate capture
- Adequate treatment
- Adequate dispersion

The last element only is important if stack design, which is associated with scrubbers, is considered.

5.5.1 - Technologies

5.5.1.1 – Change in Process

The modification or alteration of the unit process creating the odor is sometimes over-looked as an odor abatement strategy. Many times an operational modification will not change the design intent of the process, but will reduce the odor emissions. Examples of process changes include changing aeration rates or taking basins out of service.

5.5.1.2 – Chemical Addition

Chemical addition is used predominantly to control sulfides and other reduced sulfur compounds in sewer systems. Typically, these chemicals are cation salts. Other chemicals are available for treatment facilities including enzymes and bacterial compounds that will attack odors other than those created from sulfides. Chemical addition for odor control is sometimes effective when the chemical can be added to the wastewater directly to stop or inhibit the formation of odor causing compounds. Some chemicals have been formulated for addition to the air. In order for these to be effective, contact between the chemical and the air-borne constituent must occur. For this reason, the surface area of the treatment unit emitting the odor must be small in order to ensure complete contact with odorous off-gas. In general, these types of products are usually most effective when the required percent removals are less than 75%. In addition, the products are effective when the odors are caused by unusual influent wastewater characteristics. As indicated previously, the influent characteristics at Dry Creek WWTP do not appear to be unusual.

5.5.1.3 – Structural Solutions

Structural solutions consist of capture and foul air treatment. These types of solutions are used when a high percent removal is required.

5.5.1.4 - Covers

Various types of covers are used:

- Enclosures – Sometimes it is advantageous to enclose the unit process in some type of building. This allows easy access to the process. The primary disadvantage is that, assuming that the space will be occupied, the minimum air change requirement is 12 air changes per hour. In some cases, in order to ensure worker's health and safety, greater air changes are required. This greatly increases the amount of air that must be treated.

- Area covers – Area covers only cover the area that allows odorous off-gas to escape. Covers can be manufactured from steel, aluminum, fabric, fiberglass and/or wood. The design of the cover will many times depend on the structural requirements. The primary disadvantage of covers is that they limit access to the basin.

5.5.1.5 Treatment Systems

Several types of treatment systems can be used for odor control. The primary types include:

1. Scrubbers - Many types of scrubbers are available. They can be implemented individually or in combination. Typical installations include the following:

   - Packed Bed Wet Scrubbing – Scrubbers utilize a chemical reaction to remove odorous compounds. For sulfur related compounds, alkaline scrubbing can be employed. For nitrogen-based off-gases, acid scrubbing is employed. For alkaline scrubbing, the traditional chemicals are sodium hydroxide and sodium hypochlorite, although oxidants such as ozone and hydrogen peroxide can also be used.

     Packed bed scrubbers rely on recirculation to provide the retention time required for adequate gas – liquid transfer. The foul air flows upward through media. As the recirculated liquid comes in contact with the foul air, the contaminants in the air are transferred to the liquid. The spent liquid is then wasted.

   - Mist Scrubbers – Mist scrubbers also use a chemical reaction to remove odorous compounds. Presently the Dry Creek WWTP has three mist scrubber systems:

     - Dry Creek Pumping Station – single stage
     - Headworks – Single stage
     - Dewatering Area – Two stage

     The foul air flows upward through a large vessel. Chemicals are sprayed through nozzles from below to create a "mist" within the vessel. As the chemicals come in contact with the contaminants in the foul air, the contaminants are transferred to the liquid phase.

     Whereas the time for transfer in packed bed scrubbers relies on the recirculation rate, the contact time in mist scrubbers is much shorter due to no recirculation.

Wet scrubbers can be installed in stages dependent on the percent removal required. The advantage of wet scrubbing is that the percent removals achieved can be very high. Another advantage is that wet scrubbing is a controlled process. The disadvantage is that the cost of chemicals can be high if the inlet odor concentrations are high. Wet scrubbers also require maintenance.

2. Bio-filtration – Bio-filtration uses a biological process to remove odorous compounds from the foul air. Two types of bio-filters can be used: (1) bed; and (2) tower. The maximum capacity of tower bio-filters is limited, whereas the bed type can be constructed as large as necessary, assuming that space is available. In the case of Dry Creek, bed type filters would be required due to the capacities required.

   Bio-filtration has the advantage of requiring little maintenance and having no chemical cost. Because odor reduction is accomplished through a biological process, conditions that promote the growth of odor-removing bacteria must be maintained. The bed material must be continually wetted and some source of trace nutrients must be available in order to achieve acceptable removal efficiencies.

   The bio-filter bed can be constructed of several different medias. Compost type material is typically used (organic media), but inorganic and synthetic bio-filter media are also available. The inorganic type resembles lava rocks, and has the necessary trace nutrients embedded directly in the media. The inorganic media has several significant advantages. The minimum detention time required for this media is 20 to 40 seconds, depending on loading, whereas organic media beds require a one minute or greater residence time. The depth of inorganic media bio-filters can be up to 5 feet deep, while organic media beds are limited to 3 feet. Therefore, the use of inorganic bio-filters results in significantly smaller beds, an important consideration when installing new odor control units at an existing wastewater treatment plant. Other advantages of inorganic media are much longer life (10 years compared to 3 years), a long media warranty (10 years) and the ability to regenerate the media rather than replace it. For this study, the use of inorganic media has been assumed due to the space constraints.

   One disadvantage of bio-filters, assuming a bed type is used, is the space that is required. A typical design will require 1 ft^2 for every 1 – 3 cfm of air. The area can become quite large when a high volume of air requires treatment. Another disadvantage is that due to the bed type construction, the bio-filter becomes an area odor source. Little dispersion exists over the surface of the bed; therefore the required percent removals from a bio-filter need to be greater than with wet scrubbing. Finally, due to the fact that it is not a controlled process, the removal data can be inconsistent. In some cases, the removals have been reported high, whereas in other cases, the removal efficiencies have been poor.

3. Ionization – This process involves ionization of supply air to the room. The ionized oxygen molecules react with the odor causing compounds in the air to control the odors. The process is primarily used in enclosed structures and installed on the ventilation system.

   There is little data related to this process. However, where it has been applied, it has been thought to be somewhat successful.

4. Other treatment systems – Although not evaluated in this analysis due to their high capital and operating costs, carbon and fume incineration can be employed.

5.5.2 – Multiple Vs. Single Treatment Units

Another consideration is whether to install multiple treatment units at specific locations or whether to install foul air ducts to transport the foul air to a central location. The benefit of multiple units is the duplicity that is provided. However, typically, this decision is determined by the relative economics of the various alternatives.

5.5.3 – Ventilation Requirements

The following should be considered when designing an adequate odor capture system:

1. For enclosed occupied structures, adequate ventilation should occur in order to conform to OSHA worker safety limitations. In addition, for areas that could be subject to explosion potential, a minimum air change is required. Also for enclosed structures, adequate face velocities at openings should be considered to minimize fugitive escape.

2. For structures with forced air addition, the exhaust rate must be at least equal to the amount of air addition. However, in addition, adequate sweep velocities should also be ensured.

3. For structures that are unoccupied and have no air addition, adequate sweep velocity (and/or face velocities) is the principle criteria.

5.6 - Abatement Alternatives

5.6.1 - General

As indicated above, various alternatives are available for odor control, the effectiveness of which is dependent on the percent removal required. The following general conclusions are offered:

1. Process Change – Two process changes should be considered:

   - Equalization basins – The basins should be used as little as possible. As much wastewater as possible should flow directly through the treatment facility and not enter the equalization basins.

     If the basins must be used, however, the time of their use should be minimized, and the basins should be emptied as quickly as possible.

Since the exhaust rate significantly increases with aeration, it is recommended that either aeration be discontinued, or the level where the aeration is started be lowered so it will start earlier in the process.

- Aeration Basins – Assuming that the high odor level in the aeration basins is due to low dissolved oxygen, a process change should occur to ensure that the dissolved oxygen concentration is never less than 1.0 mg/L.

2. Chemical Addition – It would appear that the addition of potassium permanganate in the dewatering building did not significantly reduce the odor levels to the dewatering scrubbers. Due to this, another chemical (VX456) is currently being fed. This addition appears to be reducing odors within the building.

3. Structural Solutions – Based on the required percent removals for achieving a D/T of 5 at the property line, structural odor control will be required for the:

   - Dewatering building and solids storage tanks
   - Headworks
   - Dry Creek Pumping Station
   - Equalization basins, if process changes do not minimize the odor levels
   - Primary clarifier influent channel
   - Primary clarifier weir area
   - Primary clarifier effluent channel
   - Aeration tanks, if process changes do not minimize the odor levels

   The alternatives that follow do not include the use of the existing mist scrubbers. Based on their historical removal efficiencies and high cost of operation, it is assumed that these scrubbers will have to be abandoned.

5.6.2 – Required Capture Rates

Prior to determining the available alternatives for odor control, the air volume for each odor source must be determined. The capture rates are based on the following:

1. Ensuring that the area is being controlled under negative pressure.
2. Ensuring adequate capture velocities at all openings such as doors and windows.
3. Ensuring the safety of the operating personnel.

Table 5.2 provides the recommended capture rates.

Table 5.2
Recommended Capture Rates
Dry Creek WWTP

Location	Area (ft^2)	Air Volume (cfm)	Design Criteria	Capture Rate (cfm)
Total Primary Clarifiers	34,500	-	6 ac / h, or 1 cfm / ft^2	10,350 34,500
Primary Clarifier – Quiescent Area	31,558	-	6 ac / h, or 1 cfm / ft^2	9,467 31,558
Primary Clarifier – Weir Area	4,630	-	Exhaust Rate + 1 cfm / ft^2	6,930
Primary Clarifier Effluent Channel	2,000	-	6 ac / h, or 1 cfm / ft^2	600 2,000
Dry Creek Pumping Station	-	5,000	Air	5,000
Aeration Basins	60,630	32,000	Air + .5 cfm ft^2	62,315
Equalization Basins	89,320	-	.5 cfm / ft^2	44,660
Headworks Scrubber	-	3,000	Air	3,000
Dewatering Scrubber	-	30,000	Air	30,000
Primary Influent Channel	3,908	-	1 cfm / ft^2	3,900

5.6.3 – Available Alternatives

The alternatives analysis will not include treatment of air from the equalization basins, the quiescent area of the primary clarifiers or the aeration basins. The following alternatives will be considered:

1. Alternative 0 – Do nothing
2. Alternative 1 – Single stage packed bed scrubbing treating air from the following locations:
   - Headworks
   - Portion of the primary influent channel
3. Alternative 2 – Same as Alternative 1, but use bio-filtration in lieu of packed bed scrubbing
4. Alternative 3 – Single stage packed bed scrubbing for the remainder of the primary influent channel, the primary effluent weirs and the primary clarifier effluent channel.
5. Alternative 4 – Same as Alternative 3, but use bio-filtration in lieu of packed bed scrubbing
6. Alternative 5 – Two stage packed bed scrubbing for dewatering building, solids storage tanks and Dry Creek Pumping station.

7. Alternative 6 – Same as Alternative 5, but use bio-filtration in lieu of packed bed scrubbing
8. Alternative 7 – Bio-filtration for the headworks, primary clarifier influent channel, primary clarifier weirs and primary effluent channel.

5.6.3.1 – Discussion of Alternatives

Prior to providing capital and operating cost estimates for the above alternatives and combination of alternatives, some discussion is warranted.

Bio-filtration for Dewatering Area – The concentration of pollutants in the foul air from the solids storage tanks is higher than recommended for most bio-filters. Once the solids storage tanks have been converted to anaerobic digesters, this potential problem may be eliminated. If, however, toxicity is found to be a problem with the bio-filter in the future, single stage wet scrubbing preceding the bio-filter may be required.

5.6.3.2 – Assumed Basis of Design

Tables 5.3 and 5.4 provide the recommended basis of design for the listed alternatives.

Table 5.3
Recommended Basis of Design
Packed Bed Wet Scrubbing
Dry Creek WWTP

Alternative	Air Flow (cfm)	Design H_2S (ppm(v))	Required % Removal	Tower Diameter (ft)	Stages	Packing Depth (ft)	Recirculation Rate (gpm)
Alt 1	4,800	8	80	4	1	10	82
Alt 3	11,000	5	95	5	1	10	126
Alt 5	35,000	22[1]	90	10	2	10 Each Stage	510

[1]Actual measurement of H_2S to the existing solids scrubbers was 80 ppm(v). However, assuming the conversion to anaerobic digesters, this concentration should be reduced.

Table 5.4
Recommended Basis of Design
Bio-filtration
Dry Creek WWTP

Alternative	Air Flow (cfm)	Design H_2S (ppm(v))	Required % Removal	Residence Time (sec)	Depth (ft)	Area (ft^2)
Alt 2	4,800	8	80	20	5	317
Alt 4	11,000	5	95	30	5	1,100
Alt 6	35,000	20	90	40	5	4,690
Alt 7	16,000	6	95	30	5	1,600

5.7 – Estimates of Costs

5.7.1 – Cover Costs

Due to the leakage found from the headworks area, it is recommended that these covers be replaced.

Table 5.5 presents the estimates for covering the various unit process considered in the above alternatives.

Table 5.5
Cover Cost Estimates
Dry Creek WWTP

Alternative	Area (ft^2)	Unit Cost ($)	Total Cost ($)
Alt 1 and 2	4,530	35	159,000
Alt 3 and 4	8,745	35	306,000
Alt. 5 and 6	0	-	0
Alt 7	13,268	35	464,000

5.7.2 – Capital and Operating Costs

Tables 5.6 and 5.7 provide estimates for the capital and operating costs associated with the considered alternatives. The estimates assume the following:

- Electrical – 20% of control cost
- Site work – 20% of control + ducting costs
- Contingencies – 35%
- Engineering – 15%
- Labor for wet scrubbing - $1.00 / cfm / year, minimum $20,000 per year
- Labor for bio-filtration - $20,000 / year regardless of size
- Electrical - $.035 per kw / hr
- NaOH - $0.45 / gallon
- NaOCl - $0.73 / gallon
- Bio-filter media replacement - $24 / ft^3 – 10 year life.

Table 5.6
Capital Cost Estimates
Dry Creek WWTP

Alt.	Demolition	Covers	Control	Ducting	Subtotal	Contingency	Eng.	Total
Alt 0	0	0	0	0	0	0	0	0
Alt 1	100,000	159,000	120,000	121,000	500,000	175,000	101,000	776,000
Alt 2	100,000	159,000	300,000	121,000	680,000	238,000	138,000	1,056,000
Alt 3	-	306,000	160,000	424,000	890,000	312,000	180,000	1,382,000
Alt 4	-	306,000	330,000	424,000	1,060,000	371,000	215,000	1,646,000
Alt 5	100,000	-	600,000	-	700,000	245,000	142,000	1,087,000
Alt 6	100,000	-	1,050,000	-	1,150,000	403,000	233,000	1,786,000
Alt 7	-	464,000	480,000	803,000	1,747,000	611,000	354,000	2,712,000

Table 5.7
Annual Operating Cost Estimates
Dry Creek WWTP

Alternative	Labor[1]	Electrical	Chemicals	Media Replacement	Total
Alt 0	157,900	18,500	396,000	0	572,400
Alt 1	20,000	3,600	13,000	-	36,600
Alt 2	20,000	3,600	-	3,800	27,400
Alt 3	20,000	5,800	19,000	-	44,800
Alt 4	20,000	5,800	-	13,200	39,000
Alt 5	35,000	22,000	270,000	-	327,000
Alt 6	20,000	22,000	-	56,280	98,280
Alt 7	20,000	9,000	-	19,200	48,200

[1]Minimum labor costs $20,000.

5.7.3 – Net Present Value

In order to adequately assess the differences in costs, a net present value analysis is provided. The analysis is based on an interest rate of 5% for a term of 20 years.

The liquid train odor sources can be treated by either one system near the head works (Alt. 1 or 2) and one system near the primary clarifiers (Alt. 3 or 4), or a single system for the entire liquid train (Alt. 7). The solids train needs to be treated by a separate system due to the high cost of crossing the wide driveway area at the treatment plant (Alt. 5 or 6).

The following comparisons will be evaluated:

1. Alt 1 vs. Alt 2
2. Alt 3 vs. Alt 4
3. Alt 5 vs. Alt 6
4. Alt 7 vs. the lowest life cycle cost between Alt 1 and 2 and Alt. 3 and 4.

Table 5.8 provides the above comparisons.

Table 5.8
Net Present Value Analysis
Dry Creek WWTP

Alternative	Technology	Capital Cost ($)	Operating Cost ($)/year	Net Present Value ($)	Lowest Net Present Value
Alt 0	None	0	572,400	7,132,104	
Alt 1	Scrubber	776,000	36,600	1,232,036	
Alt 2	bio-filter	1,056,000	27,404	1,397,453	
Alt 3	Scrubber	1,382,000	44,800	1,940,208	
Alt 4	bio-filter	1,646,000	39,000	2,131,940	
Alt 5	Scrubber	1,087,000	327,000	5,161,420	
Alt 6	bio-filter	1,786,000	98,280	3,010,569	X
Alt 7	bio-filter	2,712,000	48,200	3,312,572	X

5.7.4 – Other Potential Costs

The investigation indicated that sources other than those estimated above are significant odor sources. These are the:

- Equalization basin
- Aeration tanks
- Quiescent area of the primary clarifiers

If the potential process changes do not abate the odors, structural control will be required in order to meet the objective established by Metro Water Services.

Table 5.8 provides an estimate of the capital costs for abating odors from these areas. The cost estimates assume wet scrubbing would be added. No attempt has been made to optimize the design of the control systems. As can be seen from table 5.8, the costs associated with structural control of these unit processes are significant. Therefore, every attempt should be made to minimize the odors from these processes via process change.

Table 5.8
Other Potential Costs
Dry Creek WWTP

Location	Air Flow (cfm)	Design H_2S (ppm(v))	Capital Cost ($1,000)					Operating Cost ($1,000)			
			Covers	Ducting	Control	Cont	Total	Labor	Electrical	Chemicals	Total
Equalization	90,000	2	3,150	250	2,000	2,160	7,560	45	75	63	183
Primary Clarifiers	32,000	2	3,200	150	500	1,540	5,390	32	27	22	81
Aeration	62,000	1	2,135	250	1,500	1,554	5,439	62	50	21	133

Section 6
Conclusions and Recommendations

6.1 - General

The odor and identification study verified that odors have been and are continuing to emanate from the treatment facility. The most significant sources at the Dry Creek treatment facility are (in order of significance based on transport distance):

1. The equalization basins
2. The primary clarifier weir area
3. The aeration basins
4. The exhaust from the dewatering scrubber
5. The primary influent channel
6. The exhaust from the head works scrubber
7. Dry Creek Pumping Station

6.2 – Recommended Objective

Based on discussions with Metro Water Services staff, an objective of a D/T of 5 at the property boundary has been assumed. The meteorological conditions assumed are a stability class of F and a wind speed of 1 meter/second.

6.3 – Recommended Project

It is understood that prior to implementing structural solutions for the equalization basin and the aeration basins, process changes will be implemented in the attempt to reduce the odors from these unit processes. Therefore, no structural solutions are proposed at this time for these unit processes. It should be understood, however, that these processes are still considered significant odor sources. A structural solution may be required in the future in order to meet the assumed objective.

Based on the investigation, it is also assumed that the existing scrubber systems treating air from the head works and the dewatering area will be abandoned. New control equipment will be installed.

Table 6.1 summarizes the net present values for each alternative calculated in Section 5. The net present values are group by total project for ease of comparison.

Table 6.1

Net Present Value Comparison

Description	Alt.	Capital Cost $	Operating Cost $/year	Net Present Value $
Do nothing alternative	0	0	572,400	7,132,104
Liquid Train				
Two wet scrubbers for the liquid train	1 + 3	2,158,000	81,400	3,172,244
Two bio-filters for the liquid train	2 + 4	2,702,000	66,400	3,529,344
One bio-filter for the liquid train	7	2,712,000	48,200	3,312,572
Solids Train				
Packed bed scrubber for the solids train	5	1,087,000	327,000	5,161,420
Bio-filter for the solids train	6	1,786,000	98,280	3,010,568

Do Nothing Alternative – The do nothing alternative (Alt. 0) is not feasible. Complaints from the public and compliance with Metro Health Department requirements prompted this study, and some action is required to resolve these issues.

Liquid Train Alternatives – The alternative for installing two wet scrubbers and the alternative for installing one bio-filter have virtually the same net present value. Therefore, the decision as to the selected technology must be based on factors other than cost. After lengthy discussions with Metro Water Services staff, the single bio-filter alternative is recommended. The bio-filter alternative is more environmentally friendly because it uses a naturally occurring biological process to control odors. In addition, the use of similar technology for all of the odor control systems has some advantages.

Solids Train Alternatives - The most cost effective, and therefore the recommended alternative, is the bio-filter alternative.

Based on the alternatives analysis, the following project is recommended:

1. Install a bio-filter to treat the air from the head works, primary influent channel, the weir area of the primary clarifiers and the primary effluent channel. Design criteria for this bio-filter is as follows:

Required Percent Removal:	98
Capacity:	11,000 cfm
Depth:	5 feet
Detention Time:	20 sec.

2. Install a second bio-filter to treat the air from the solids storage

tanks, dewatering building and the Dry Creek pumping station.

The design criteria for the bio-filter is as follows:

Required Percent Removal:	96
Capacity:	35,000 cfm
Depth:	5 feet
Detention Time:	40 sec.

The estimated capital cost for the above project is $4,498,000.

6.4 – Recommendation Details

6.4.1 - Covers

The type of cover can either be aluminum, fiberglass or fabric. The choice is dependent on economics and preference. All have been used with satisfactory results.

It is recommended that specifications be written to allow all three types of covers, unless there is a preferred type.

Covers should be designed with the following considerations:

1. The removal of the cover(s) may be required in order to provide maintenance on the internal equipment or for the replacement of equipment. Consideration must be given, therefore, as to how the cover can be removed.
2. Adequate hatches should be provided to allow for inspection of the basins. The design should ensure that the hatches can be tightly sealed when closed.
3. If fabric covers are selected, adequate drainage should be provided.

6.4.2 - Ducting

Cost estimates for the ducting provide for separate duct runs from each odor source, rather than combining the sources into a single duct to the bio-filter. This concept provides for redundancy, and should be included in the final design.

Ducting from the various unit processes to the odor control systems should be constructed above ground to ensure that condensate does not collect in the low points of the duct. Drain ports for condensate drainage should be provided.

Since it would appear that road crossings will be required, adequate support should be designed since the height of the duct at the crossings could be considerable.

Dampers should be provided to allow for balancing of the system. These dampers should be able to be accurately adjusted to ensure proper balancing.

6.4.3 – Bio-filter Design

The following is recommended for the design of the bio-filter:

1. A synthetic media is recommended to allow for reduced bio-filter size and longer media life. This type of media is more expensive than the older compost type media, but the life is much longer (10 years compared to 3).
2. The bio-filter media should be pre-purchased to allow detailed design around one particular manufacturer. This will result in significantly lower engineering costs and will allow better control by Metro Water

Services over the media selected. The media manufacturer should also furnish the air distribution system equipment, humidification equipment and fans in order to have a sole source of responsibility for the compliance of the bio-filtration system with the odor removal requirements.

3. Performance testing of the odor removal equipment should be required. Testing should occur after the equipment has been in operation for some period of time.

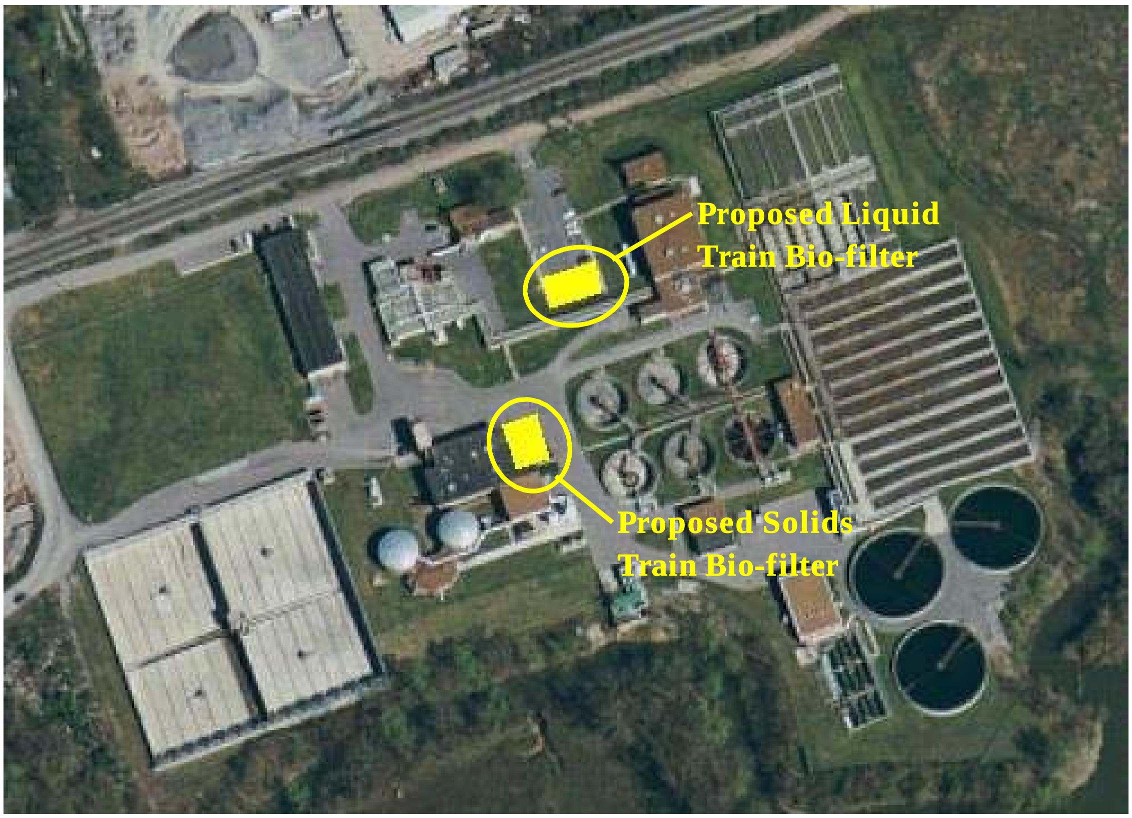

Figure 6.1
Dry Creek WWTP
Proposed Bio-filter Locations

Focus Group Information

Dry Creek WWTP Focus Group

Lillian Thomas
Sheperds Hill Dr.

Harvey Hertenstein
Sheperds Hill Dr.

Beverly Reese
Glen Circle Dr.

Susan Upchurch
Spring Branch Dr.

Gerlie Rickard
Twin Hills Dr

Theresa Webb
Cornerstone @ Rivergate
Twin Hills Dr.

Phil Novelli
Logan's Roadhouse
Gallatin Pk. North

Pam Pace
Calhouns
Gallatin Rd. North

Steve Norman
Red Lobster
Gallatin Rd. North

Metro Water Services
Comprehensive Odor Study

Focus Group Meeting #1
Dry Creek WWTP

October 9, 2001

AGENDA

1. **Introductions**

2. **Establish Objectives of Focus Group**

3. **Definition of an Odor Problem**

4. **Brief Discussion on Odor Science**

5. **Odor Study Steps**

6. **Schedule of Tasks**

7. **Odor Occurrence Logs**

8. **Next Meeting Objectives and Potential Date**

9. **Discussion**

Definition of an Odor Problem

1. **Odor Source**
    - Incoming wastewater
    - Treatment processes within facility
2. **Release**
    - Open tanks
    - Channels
    - Vents
    - Fans
3. **Transport**
    - Meteorological conditions
    - Low wind speed
    - High stability
4. **Receptor (Nose)**
    - Location
    - Threshold of odor
    - Perception of odor

Basic Principles of Odor Science

1. **Odor constituents**

    - Odors from waste treatment facilities are comprised of numerous constituents

    - Constituents in low concentrations are not a concern to public health

    - Odors are considered a “nuisance”

2. Distance of **odor transport** dependent on “Odor emission rate” (OER) – OER is equal to the concentration of odor times the amount of air being emitted

3. **Threshold science**

    - Must reduce odor concentration below threshold concentration <u>at the receptor location</u>

    - Reducing the concentration well below the threshold could result in high costs with little additional benefit

4. Odors from different sources are **not necessarily additive**

    - Must determine the source (odor) which travels the farthest

    - Eliminating lesser odors will not provide benefit

Odor Study Steps

1. Determine all potential sources of odors
2. Sample and analyze air from all potential sources
3. Determine air exhaust rates from all potential sources
4. Calculate odor emission rates from each source
5. Rank all data (worst to best)
6. Model (screen) data to determine maximum distance that each odor (from each potential source) will travel during varying weather conditions
7. Establish Objectives - These objectives may include:
   - Acceptable odor level at: (1) receptors (off-site) or; (2) property line
   - Acceptable frequency of odor occurrences
   - Cost budget
8. Determine % removal to meet above objectives
9. Analyze and characterize odorous air from problem sources
10. Determine the alternatives for reducing odor (from each source) to meet above % removals
11. Evaluate alternatives based on:
    - Meeting above objectives
    - Cost
    - Long term implications
    - Other
12. Select alternative
13. Design

Schedule of Tasks

1. Determine all potential sources - complete
2. Sample and analyze air from all potential sources – complete
3. Determine air exhaust rates – 50 percent complete
4. Calculate odor emission rates – 50 percent complete
5. Determine distances – November, 2001
6. Odor Ranking – November, 2001
7. Technical Memorandum #1 – November, 2001
8. Focus Group Meeting #2 – November, 2001
9. % Removal Determination – December, 2001
10. Alternatives Screening – December, 2001
11. Technical Memorandum #2 – December, 2001
12. Focus Group Meeting #3 – December, 2001
13. Draft Report Preparation – January, 2002
14. Final Report – February, 2002

Focus Group Meeting #2

Preliminary Agenda

1. Review all data

2. Review modeling (screen) results

3. Establish Objectives

Comprehensive Odor Evaluation
Focus Group Meeting
January 28, 2002

AGENDA

1. Review Study Steps
2. Review Sample Locations
3. Discuss Sampling Results
4. Present Transport Model Results
5. Discuss Odor Priority
6. Discuss Abatement Objective

Model Results

Table 1
Base Data

Nashville - Dry Creek

Name of Facility	Nashville - Dry Creek							
Date of Run	04/29/03							
Number of Sources	29							
Dilution Series 1	27	7	1					
Dilution Series 2	567	189	1					
Turbulence Factors	**None**	0.05	**Light**	0.1	**Moderate**	0.2	**High**	0.3
Endpoints	**Avg**	1	**Peak**	1	5			
Slope Correction	**Avg**	-0.3	**Peak**	-0.5	**niting D/T**	100	**niting D/T**	500
Peaking Factors	**Area**	10	**Point**	3	**iiting OEF**	0.2	**iiting OEF**	0.5
Design Average	x	5						
Design Peak	x	1						

Sample Type Factors

Source Information **A,P or V 1 = None 2 = Light 3 = Mod 4 = High**

	Sample Information						**Base Sensory Data**								**Source Information**		
Sample #	**Sample Location**	**Date**	**Time**	**Sample Type**	**Factor**	**Process ID**	**D/T**	**Dil 3**	**Dil 2**	**Dil 1**	**Dil Series**	**H2S**	**Mer**	**NH3**	**Area**	**cfm**	**Height**
1	Primary Channel Influent	08/20/01	-	V	-	PRICH1	289	71	114	191	1	1.3	0	0	3908	2500	5
2	Primary Clarifier Influent	08/16/01	-	A	1	PRIQ	217	33	60	174	1	0.22	0	0	11500		5
3	Primary Clarifier Midpoint	08/16/01	-	A	1	PRIQ	128	56	73	351	1	0.4	0	0.05	11500		5
4	Primary Clarifier Weir 1	08/16/01	-	A	3	PRIW	1362	197	466	502	1	6.6	0	0	11500		5
5	Primary Effluent Channel	08/20/01	-	V	-	PRICH2	44	36	112	265	1	0.15	0	0	4650	3000	5
6	Aeration Basin Influent (1)	08/06/01	-	V	-	AB3	87	28	30	35	1	0.13	0	0	20210	10667	5
7	Aeration Basin Midpoint (1)	08/06/01	-	V	-	AB4	26	18	25	19	1	0.007	0	0	20210	10667	5
8	Aeration Basin End (1)	08/06/01	-	V	-	AB5	14	18	21	23	1	0.002	0	0	20210	10667	5
9	Mixed Liquor Channel	08/06/01	-	V	-	FINCH	14	16	16	16	1	0.003	0	0	3867	2500	5
10	Final Clarifier	08/20/01	-	A	1	FINQ	12	11	13	16	1	0.014	0	0	34383		5
11	EQ Basin - 20 ft.	08/06/01	-	A	2	REQUAL	840	92	107	122	1	0.13	0	1.1	89320		20
12	Dewatered Sludge w/Permanganate	08/22/01	-	A	1	DSTORE	457	121	228	502	1	2.2	0	0	72		-
13	Dewatered Sludge w/o Permanganate	08/22/01	-	A	1	DSTORE	327	121	232	419	1	3	0	0	72		-
14	Dewatering Bldg. w/ Permanganate	08/22/01	-	P	-	DWDP	249	42	94	173	1	7.4	0	0			-
15	Dewatering Bldg. w/o Permanganate	08/22/01	-	P	-	DWDP	618	81	225	419	1	17	0	0			-
16	Solids Scrubber Exhaust 1	08/16/01	-	P	-	WSCRUB	325	51	71	232	2	6.6	0	0	15.9	30000	30
17	Headworks Scrubber Exhaust	08/20/01	-	P	-	WSCRUB	550	144	299	381	1	0	0	-	3.14	3000	23.25
18	Total Primaries	-	-	A	2	-	408	79	165	297	1	-	-	-	43058		-
19	Total Aeration 1	-	-	V	-	-	42	21	25	26	1	-	-	-	60630	32001	-
20	EQ Basin - 14 ft.	10/08/01	-	A	2	REQUAL	584	135	314	544	1	0.26	0	0	89320		20
21	Dry Creek Lift Station	10/08/01	-	P	-	WW	191	46	124	228	1	0.57	0	0		5000	15
22	Primaries w/o Weir Area	-	-	A	1	-	170	49	90	245	1	-	-	-	31558		-
23	Solids Scrubber Exhaust 2	11/26/01	-	P	-	WSCRUB	565	355	500	774	1	8	0	0		30000	-
24	Primary Clarifier Midpoint (2)	02/25/02	-	A	1	PRIQ	15	8	9	15	1	0	0	0	11500		-
25	Primary Clarifier Weir 2	02/25/02	-	A	3	PRIW	50	23	36	50	1	0	0.2	0	11500		-
26	Aeration Basin Influent (2)	02/25/02	-	V	-	AB3	329	71	177	331	1	0	0.5	0.3	20210	10667	-
27	Aeration Basin Midpoint (2)	02/25/02	-	V	-	AB4	133	28	51	60	1	0	0	0.1	20210	10667	-
28	Aeration Basin End (2)	02/25/02	-	V	-	AB5	113	55	102	193	1	0	0	0	20210	10667	-
29	Total Aeration 2	-	-	V	-	-	192	51	110	195	1	-	-	-	60,630	32,001	-

Table 2
Sensory Data

Nashville - Dry Creek

	Sample										Dose -Response Data				
Sample #	Type	Sample Location	D/T		Dilutions				Logs			m	b	r	Test
1	V	Primary Channel Influent	289	71	114	191	1.8513	2.0569	2.2810	2.4609		-0.1746	2.1956	-0.997	Okay
2	A	Primary Clarifier Influent	217	33	60	174	1.5185	1.7782	2.2405	2.3365		-0.3090	2.0802	-0.998	Okay
3	A	Primary Clarifier Midpoint	128	56	73	351	1.7482	1.8633	2.5453	2.1072		-0.3783	2.3393	-0.96	Okay
4	A	Primary Clarifier Weir 1	1362	197	466	502	2.2945	2.6684	2.7007	3.1342		-0.1296	2.6529	-0.849	Check
5	V	Primary Effluent Channel	44	36	112	265	1.5563	2.0492	2.4232	1.6435		-0.5275	2.4099	-0.983	Okay
6	V	Aeration Basin Influent (1)	87	28	30	35	1.4472	1.4771	1.5441	1.9395		-0.0500	1.5274	-0.994	Okay
7	V	Aeration Basin Midpoint (1)	26	18	25	19	1.2553	1.3979	1.2788	1.4150		-0.0166	1.3232	-0.05	Check
8	V	Aeration Basin End (1)	14	18	21	23	1.2553	1.3222	1.3617	1.1461		-0.0929	1.3836	-0.968	Okay
9	V	Mixed Liquor Channel	14	16	16	16	1.2041	1.2041	1.2041	1.1461		0.0000	1.2041	0	Check
10	A	Final Clarifier	12	11	13	16	1.0414	1.1139	1.2041	1.0792		-0.1508	1.2342	-0.999	Okay
11	A	EQ Basin - 20 ft.	840	92	107	122	1.9638	2.0294	2.0864	2.9243		-0.0419	2.0583	-0.99	Okay
12	A	Dewatered Sludge w/Permanganate	457	121	228	502	2.0828	2.3579	2.7007	2.6599		-0.2323	2.5568	-0.999	Okay
13	A	Dewatered Sludge w/o Permanganate	327	121	232	419	2.0828	2.3655	2.6222	2.5145		-0.2145	2.5196	-0.991	Okay
14	P	Dewatering Bldg. w/ Permanganate	249	42	94	173	1.6232	1.9731	2.2380	2.3962		-0.2566	2.1395	-0.983	Okay
15	P	Dewatering Bldg. w/o Permanganate	618	81	225	419	1.9085	2.3522	2.6222	2.7910		-0.2557	2.4883	-0.97	Okay
16	P	Solids Scrubber Exhaust 1	325	51	71	232	1.7076	1.8513	2.3655	2.5119		-0.2619	2.4139	-0.999	Okay
17	P	Headworks Scrubber Exhaust	550	144	299	381	2.1584	2.4757	2.5809	2.7404		-0.1542	2.5220	-0.926	Okay
18	A	Total Primaries	408	79	165	297	1.8954	2.2175	2.4722	2.6107		-0.2209	2.3627	-0.985	Okay
19	V	Total Aeration 1	42.33	21	25	26	1.3291	1.4037	1.4094	1.6267		-0.0494	1.4182	-0.845	Check
20	A	EQ Basin - 14 ft.	584	135	314	544	2.1303	2.4969	2.7356	2.7664		-0.2188	2.6203	-0.975	Okay
21	P	Dry Creek Lift Station	191	46	124	228	1.6628	2.0934	2.3579	2.2810		-0.3048	2.2693	-0.971	Okay
22	A	Primaries w/o Weir Area	169.5	49	90	245	1.6902	1.9530	2.3896	2.2292		-0.3138	2.2490	-0.999	Okay
23	P	Solids Scrubber Exhaust 2	565	355	500	774	2.5502	2.6990	2.8887	2.7520		-0.1230	2.8060	-0.999	Okay
24	A	Primary Clarifier Midpoint (2)	15	8	9	15	0.9031	0.9542	1.1761	1.1761		-0.2321	1.1873	-0.971	Okay
25	A	Primary Clarifier Weir 2	50	23	36	50	1.3617	1.5563	1.6990	1.6990		-0.1985	1.6896	-0.981	Okay
26	V	Aeration Basin Influent (2)	329	71	177	331	1.8513	2.2480	2.5198	2.5172		-0.2656	2.4079	-0.978	Okay
27	V	Aeration Basin Midpoint (2)	133	28	51	60	1.4472	1.7076	1.7782	2.1239		-0.1558	1.7626	-0.912	Okay
28	V	Aeration Basin End (2)	113	55	102	193	1.7404	2.0086	2.2856	2.0531		-0.2655	2.2130	-0.996	Okay
29	V	Total Aeration 2	191.7	51	110	195	1.7104	2.0414	2.2893	2.2825		-0.2536	2.2061	-0.983	Okay

Table 3
Exhaust Rates

Nashville - Dry Creek

Sample #	Sample Location	Sample Type	Area (ft^3)	Area (m^3)	Total Exhaust Rate (ft^3/min)	Total Exhaust Rate (m3/sec)	Unit Exhaust Rate (ft3/min/ft2)	Unit Exhaust Rate (m3/sec/m2)
1	Primary Channel Influent	V	3908	363.05	2500	1.18	0.640	0.0033
2	Primary Clarifier Influent	A	11500	1068.35	575	0.27	0.050	0.0003
3	Primary Clarifier Midpoint	A	11500	1068.35	575	0.27	0.050	0.0003
4	Primary Clarifier Weir 1	A	11500	1068.35	2300	1.09	0.200	0.0010
5	Primary Effluent Channel	V	4650	431.99	3000	1.42	0.645	0.0033
6	Aeration Basin Influent (1)	V	20210	1877.51	10667	5.03	0.528	0.0027
7	Aeration Basin Midpoint (1)	V	20210	1877.51	10667	5.03	0.528	0.0027
8	Aeration Basin End (1)	V	20210	1877.51	10667	5.03	0.528	0.0027
9	Mixed Liquor Channel	V	3867	359.24	2500	1.18	0.646	0.0033
10	Final Clarifier	A	34383	3194.18	1719	0.81	0.050	0.0003
11	EQ Basin - 20 ft.	A	89320	8297.83	8932	4.22	0.100	0.0005
12	Dewatered Sludge w/Permanganate	A	72	6.69	4	0.00	0.050	0.0003
13	Dewatered Sludge w/o Permanganate	A	72	6.69	4	0.00	0.050	0.0003
14	Dewatering Bldg. w/ Permanganate	P			0	0.00	Point	Point
15	Dewatering Bldg. w/o Permanganate	P			0	0.00	Point	Point
16	Solids Scrubber Exhaust 1	P	15.9	1.48	30000	14.16	Point	Point
17	Headworks Scrubber Exhaust	P	3.14	0.29	3000	1.42	Point	Point
18	Total Primaries	A	43058	4000.09	4306	2.03	0.100	0.0005
19	Total Aeration 1	V	60630	5632.53	32001	15.10	0.528	0.0027
20	EQ Basin - 14 ft.	A	89320	8297.83	8932	4.22	0.100	0.0005
21	Dry Creek Lift Station	P			5000	2.36	Point	Point
22	Primaries w/o Weir Area	A	31558	2931.74	1578	0.74	0.050	0.0003
23	Solids Scrubber Exhaust 2	P			30000	14.16	Point	Point
24	Primary Clarifier Midpoint (2)	A	11500	1068.35	575	0.27	0.050	0.0003
25	Primary Clarifier Weir 2	A	11500	1068.35	2300	1.09	0.200	0.0010
26	Aeration Basin Influent (2)	V	20210	1877.51	10667	5.03	0.528	0.0027
27	Aeration Basin Midpoint (2)	V	20210	1877.51	10667	5.03	0.528	0.0027
28	Aeration Basin End (2)	V	20210	1877.51	10667	5.03	0.528	0.0027
29	Total Aeration 2	V	60630	5632.53	32001	15.10	0.528	0.0027

Table 4
Odor Emission Rates

Nashville - Dry Creek

Sample #	Sample Location	Odor Emission Rate (O.U.-ft^3/min X 10^6)	Odor Emission Rate (O.U.-m^3/sec)	Butanol Odor Emission Rate (gr/sec)
1	Primary Channel Influent	0.72250	341.0	0.7
2	Primary Clarifier Influent	0.12478	58.9	0.1
3	Primary Clarifier Midpoint	0.07360	34.7	0.3
4	Primary Clarifier Weir 1	3.13260	1478.6	1.6
5	Primary Effluent Channel	0.13200	62.3	1.1
6	Aeration Basin Influent (1)	0.92803	438.0	0.5
7	Aeration Basin Midpoint (1)	0.27734	130.9	0.3
8	Aeration Basin End (1)	0.14934	70.5	0.3
9	Mixed Liquor Channel	0.03500	16.5	0.1
10	Final Clarifier	0.02063	9.7	0.0
11	EQ Basin - 20 ft.	7.50288	3541.4	1.6
12	Dewatered Sludge w/Permanganate	0.00165	0.8	0.0
13	Dewatered Sludge w/o Permanganate	0.00118	0.6	0.0
14	Dewatering Bldg. w/ Permanganate	0.00000	0.0	0.0
15	Dewatering Bldg. w/o Permanganate	0.00000	0.0	0.0
16	Solids Scrubber Exhaust 1	9.75000	4602.0	9.9
17	Headworks Scrubber Exhaust	1.65000	778.8	1.6
18	Total Primaries	4.18548	1975.5	3.9
19	Total Aeration 1	1.38971	655.9	1.2
20	EQ Basin - 14 ft.	5.21629	2462.1	6.9
21	Dry Creek Lift Station	0.95500	450.8	1.6
22	Primaries w/o Weir Area	0.26745	126.2	0.6
23	Solids Scrubber Exhaust 2	16.95000	8000.4	33.1
24	Primary Clarifier Midpoint (2)	0.00863	4.1	0.0
25	Primary Clarifier Weir 2	0.11500	54.3	0.2
26	Aeration Basin Influent (2)	3.50944	1656.5	5.0
27	Aeration Basin Midpoint (2)	1.41871	669.6	0.9
28	Aeration Basin End (2)	1.20537	568.9	2.9
29	Total Aeration 2	6.13353	2895.0	8.9

Table 5
D/T Sort

Nashville - Dry Creek

Sample #	Sample Location	D/T	Rank	Sample #	Sample Location	D/T	Rank
1	Primary Channel Influent	289	12	4	Primary Clarifier Weir 1	1362	1
2	Primary Clarifier Influent	217	14	11	EQ Basin - 20 ft.	840	2
3	Primary Clarifier Midpoint	128	19	15	Dewatering Bldg. w/o Permanganate	618	3
4	Primary Clarifier Weir 1	1362	1	20	EQ Basin - 14 ft.	584	4
5	Primary Effluent Channel	44	23	23	Solids Scrubber Exhaust 2	565	5
6	Aeration Basin Influent (1)	87	21	17	Headworks Scrubber Exhaust	550	6
7	Aeration Basin Midpoint (1)	26	25	12	Dewatered Sludge w/Permanganate	457	7
8	Aeration Basin End (1)	14	27	18	Total Primaries	408	8
9	Mixed Liquor Channel	14	28	26	Aeration Basin Influent (2)	329	9
10	Final Clarifier	12	29	13	Dewatered Sludge w/o Permanganate	327	10
11	EQ Basin - 20 ft.	840	2	16	Solids Scrubber Exhaust 1	325	11
12	Dewatered Sludge w/Permanganate	457	7	1	Primary Channel Influent	289	12
13	Dewatered Sludge w/o Permanganate	327	10	14	Dewatering Bldg. w/ Permanganate	249	13
14	Dewatering Bldg. w/ Permanganate	249	13	2	Primary Clarifier Influent	217	14
15	Dewatering Bldg. w/o Permanganate	618	3	29	Total Aeration 2	192	15
16	Solids Scrubber Exhaust 1	325	11	21	Dry Creek Lift Station	191	16
17	Headworks Scrubber Exhaust	550	6	22	Primaries w/o Weir Area	170	17
18	Total Primaries	408	8	27	Aeration Basin Midpoint (2)	133	18
19	Total Aeration 1	42	24	3	Primary Clarifier Midpoint	128	19
20	EQ Basin - 14 ft.	584	4	28	Aeration Basin End (2)	113	20
21	Dry Creek Lift Station	191	16	6	Aeration Basin Influent (1)	87	21
22	Primaries w/o Weir Area	170	17	25	Primary Clarifier Weir 2	50	22
23	Solids Scrubber Exhaust 2	565	5	5	Primary Effluent Channel	44	23
24	Primary Clarifier Midpoint (2)	15	26	19	Total Aeration 1	42	24
25	Primary Clarifier Weir 2	50	22	7	Aeration Basin Midpoint (1)	26	25
26	Aeration Basin Influent (2)	329	9	24	Primary Clarifier Midpoint (2)	15	26
27	Aeration Basin Midpoint (2)	133	18	8	Aeration Basin End (1)	14	27
28	Aeration Basin End (2)	113	20	9	Mixed Liquor Channel	14	28
29	Total Aeration 2	192	15	10	Final Clarifier	12	29

Table 6
OER Sort

Nashville - Dry Creek

Sample #	Sample Location	OER	Rank	Sample #	Sample Location	OER	Rank
1	Primary Channel Influent	0.72250	15	23	Solids Scrubber Exhaust 2	16.950	1
2	Primary Clarifier Influent	0.12478	20	16	Solids Scrubber Exhaust 1	9.750	2
3	Primary Clarifier Midpoint	0.07360	22	11	EQ Basin - 20 ft.	7.503	3
4	Primary Clarifier Weir 1	3.13260	8	29	Total Aeration 2	6.134	4
5	Primary Effluent Channel	0.13200	19	20	EQ Basin - 14 ft.	5.216	5
6	Aeration Basin Influent (1)	0.92803	14	18	Total Primaries	4.185	6
7	Aeration Basin Midpoint (1)	0.27734	16	26	Aeration Basin Influent (2)	3.509	7
8	Aeration Basin End (1)	0.14934	18	4	Primary Clarifier Weir 1	3.133	8
9	Mixed Liquor Channel	0.03500	23	17	Headworks Scrubber Exhaust	1.650	9
10	Final Clarifier	0.02063	24	27	Aeration Basin Midpoint (2)	1.419	10
11	EQ Basin - 20 ft.	7.50288	3	19	Total Aeration 1	1.390	11
12	Dewatered Sludge w/Permanganate	0.00165	26	28	Aeration Basin End (2)	1.205	12
13	Dewatered Sludge w/o Permanganate	0.00118	27	21	Dry Creek Lift Station	0.955	13
14	Dewatering Bldg. w/ Permanganate	0.00000	28	6	Aeration Basin Influent (1)	0.928	14
15	Dewatering Bldg. w/o Permanganate	0.00000	29	1	Primary Channel Influent	0.723	15
16	Solids Scrubber Exhaust 1	9.75000	2	7	Aeration Basin Midpoint (1)	0.277	16
17	Headworks Scrubber Exhaust	1.65000	9	22	Primaries w/o Weir Area	0.267	17
18	Total Primaries	4.18548	6	8	Aeration Basin End (1)	0.149	18
19	Total Aeration 1	1.38971	11	5	Primary Effluent Channel	0.132	19
20	EQ Basin - 14 ft.	5.21629	5	2	Primary Clarifier Influent	0.125	20
21	Dry Creek Lift Station	0.95500	13	25	Primary Clarifier Weir 2	0.115	21
22	Primaries w/o Weir Area	0.26745	17	3	Primary Clarifier Midpoint	0.074	22
23	Solids Scrubber Exhaust 2	16.95000	1	9	Mixed Liquor Channel	0.035	23
24	Primary Clarifier Midpoint (2)	0.00863	25	10	Final Clarifier	0.021	24
25	Primary Clarifier Weir 2	0.11500	21	24	Primary Clarifier Midpoint (2)	0.009	25
26	Aeration Basin Influent (2)	3.50944	7	12	Dewatered Sludge w/Permanganate	0.002	26
27	Aeration Basin Midpoint (2)	1.41871	10	13	Dewatered Sludge w/o Permanganate	0.001	27
28	Aeration Basin End (2)	1.20537	12	14	Dewatering Bldg. w/ Permanganate	0.000	28
29	Total Aeration 2	6.13353	4	15	Dewatering Bldg. w/o Permanganate	0.000	29

Table 7
Intensity Sort

Nashville - Dry Creek

Sample #	Sample Location	Intensity	Rank	Sample #	Sample Location	Intensity	Rank
1	Primary Channel Influent	0.681	15	23	Solids Scrubber Exhaust 2	33.103	1
2	Primary Clarifier Influent	0.143	22	16	Solids Scrubber Exhaust 1	9.922	2
3	Primary Clarifier Midpoint	0.288	20	29	Total Aeration 2	8.881	3
4	Primary Clarifier Weir 1	1.646	8	20	EQ Basin - 14 ft.	6.927	4
5	Primary Effluent Channel	1.133	13	26	Aeration Basin Influent (2)	5.034	5
6	Aeration Basin Influent (1)	0.532	17	18	Total Primaries	3.891	6
7	Aeration Basin Midpoint (1)	0.289	19	28	Aeration Basin End (2)	2.935	7
8	Aeration Basin End (1)	0.350	18	4	Primary Clarifier Weir 1	1.646	8
9	Mixed Liquor Channel	0.057	23	17	Headworks Scrubber Exhaust	1.629	9
10	Final Clarifier	0.039	24	21	Dry Creek Lift Station	1.625	10
11	EQ Basin - 20 ft.	1.554	11	11	EQ Basin - 20 ft.	1.554	11
12	Dewatered Sludge w/Permanganate	0.003	26	19	Total Aeration 1	1.228	12
13	Dewatered Sludge w/o Permanganate	0.002	27	5	Primary Effluent Channel	1.133	13
14	Dewatering Bldg. w/ Permanganate	0.000	28	27	Aeration Basin Midpoint (2)	0.912	14
15	Dewatering Bldg. w/o Permanganate	0.000	29	1	Primary Channel Influent	0.681	15
16	Solids Scrubber Exhaust 1	9.922	2	22	Primaries w/o Weir Area	0.552	16
17	Headworks Scrubber Exhaust	1.629	9	6	Aeration Basin Influent (1)	0.532	17
18	Total Primaries	3.891	6	8	Aeration Basin End (1)	0.350	18
19	Total Aeration 1	1.228	12	7	Aeration Basin Midpoint (1)	0.289	19
20	EQ Basin - 14 ft.	6.927	4	3	Primary Clarifier Midpoint	0.288	20
21	Dry Creek Lift Station	1.625	10	25	Primary Clarifier Weir 2	0.164	21
22	Primaries w/o Weir Area	0.552	16	2	Primary Clarifier Influent	0.143	22
23	Solids Scrubber Exhaust 2	33.103	1	9	Mixed Liquor Channel	0.057	23
24	Primary Clarifier Midpoint (2)	0.012	25	10	Final Clarifier	0.039	24
25	Primary Clarifier Weir 2	0.164	21	24	Primary Clarifier Midpoint (2)	0.012	25
26	Aeration Basin Influent (2)	5.034	5	12	Dewatered Sludge w/Permanganate	0.003	26
27	Aeration Basin Midpoint (2)	0.912	14	13	Dewatered Sludge w/o Permanganate	0.002	27
28	Aeration Basin End (2)	2.935	7	14	Dewatering Bldg. w/ Permanganate	0.000	28
29	Total Aeration 2	8.881	3	15	Dewatering Bldg. w/o Permanganate	0.000	29

Table 8
Combined Sort

Nashville - Dry Creek

D/T Sample Location	OER Sample Location	Intensity Sample Location
Primary Clarifier Weir 1	Solids Scrubber Exhaust 2	Solids Scrubber Exhaust 2
EQ Basin - 20 ft.	Solids Scrubber Exhaust 1	Solids Scrubber Exhaust 1
Dewatering Bldg. w/o Permanganate	EQ Basin - 20 ft.	Total Aeration 2
EQ Basin - 14 ft.	Total Aeration 2	EQ Basin - 14 ft.
Solids Scrubber Exhaust 2	EQ Basin - 14 ft.	Aeration Basin Influent (2)
Headworks Scrubber Exhaust	Total Primaries	Total Primaries
Dewatered Sludge w/Permanganate	Aeration Basin Influent (2)	Aeration Basin End (2)
Total Primaries	Primary Clarifier Weir 1	Primary Clarifier Weir 1
Aeration Basin Influent (2)	Headworks Scrubber Exhaust	Headworks Scrubber Exhaust
Dewatered Sludge w/o Permanganate	Aeration Basin Midpoint (2)	Dry Creek Lift Station
Solids Scrubber Exhaust 1	Total Aeration 1	EQ Basin - 20 ft.
Primary Channel Influent	Aeration Basin End (2)	Total Aeration 1
Dewatering Bldg. w/ Permanganate	Dry Creek Lift Station	Primary Effluent Channel
Primary Clarifier Influent	Aeration Basin Influent (1)	Aeration Basin Midpoint (2)
Total Aeration 2	Primary Channel Influent	Primary Channel Influent
Dry Creek Lift Station	Aeration Basin Midpoint (1)	Primaries w/o Weir Area
Primaries w/o Weir Area	Primaries w/o Weir Area	Aeration Basin Influent (1)
Aeration Basin Midpoint (2)	Aeration Basin End (1)	Aeration Basin End (1)
Primary Clarifier Midpoint	Primary Effluent Channel	Aeration Basin Midpoint (1)
Aeration Basin End (2)	Primary Clarifier Influent	Primary Clarifier Midpoint
Aeration Basin Influent (1)	Primary Clarifier Weir 2	Primary Clarifier Weir 2
Primary Clarifier Weir 2	Primary Clarifier Midpoint	Primary Clarifier Influent
Primary Effluent Channel	Mixed Liquor Channel	Mixed Liquor Channel
Total Aeration 1	Final Clarifier	Final Clarifier
Aeration Basin Midpoint (1)	Primary Clarifier Midpoint (2)	Primary Clarifier Midpoint (2)
Primary Clarifier Midpoint (2)	Dewatered Sludge w/Permanganate	Dewatered Sludge w/Permanganate
Aeration Basin End (1)	Dewatered Sludge w/o Permanganate	Dewatered Sludge w/o Permanganate
Mixed Liquor Channel	Dewatering Bldg. w/ Permanganate	Dewatering Bldg. w/ Permanganate
Final Clarifier	Dewatering Bldg. w/o Permanganate	Dewatering Bldg. w/o Permanganate

Table 9
Average Model Input Data

Nashville - Dry Creek

Sample #	Sample Location	Initial D/T x m3/sec	Final D/T x m3/sec	Slope Correction	Final Endpoint
23	Solids Scrubber Exhaust 2	8000.40	1.00	-0.3	0.410
16	Solids Scrubber Exhaust 1	4602.00	1.00	-0.3	0.873
11	EQ Basin - 20 ft.	3541.36	1.00	-0.3	0.140
29	Total Aeration 2	2895.02	1.00	-0.3	0.845
20	EQ Basin - 14 ft.	2462.09	1.00	-0.3	0.729
18	Total Primaries	1975.54	1.00	-0.3	0.736
26	Aeration Basin Influent (2)	1656.46	1.00	-0.3	0.885
4	Primary Clarifier Weir 1	1478.59	1.00	-0.3	0.432
17	Headworks Scrubber Exhaust	778.80	1.00	-0.3	0.514
27	Aeration Basin Midpoint (2)	669.63	1.00	-0.3	0.519
19	Total Aeration 1	655.94	1.00	-0.3	0.165
28	Aeration Basin End (2)	568.94	1.00	-0.3	0.885
21	Dry Creek Lift Station	450.76	1.00	-0.3	1.016
6	Aeration Basin Influent (1)	438.03	1.00	-0.3	0.167
1	Primary Channel Influent	341.02	1.00	-0.3	0.582
7	Aeration Basin Midpoint (1)	130.91	1.00	-0.3	0.055
22	Primaries w/o Weir Area	126.24	1.00	-0.3	1.046
8	Aeration Basin End (1)	70.49	1.00	-0.3	0.310
5	Primary Effluent Channel	62.30	1.00	-0.3	1.758
2	Primary Clarifier Influent	58.89	1.00	-0.3	1.030
25	Primary Clarifier Weir 2	54.28	1.00	-0.3	0.662
3	Primary Clarifier Midpoint	34.74	1.00	-0.3	1.261
9	Mixed Liquor Channel	16.52	1.00	-0.3	0.000
10	Final Clarifier	9.74	1.00	-0.3	0.503
24	Primary Clarifier Midpoint (2)	4.07	1.00	-0.3	0.774
12	Dewatered Sludge w/Permanganate	0.78	1.00	-0.3	0.774
13	Dewatered Sludge w/o Permanganate	0.56	1.00	-0.3	0.715
14	Dewatering Bldg. w/ Permanganate	0.00	1.00	-0.3	0.855
15	Dewatering Bldg. w/o Permanganate	0.00	1.00	-0.3	0.852

Table 10
Peak Model Input Data
Nashville - Dry Creek

Sample #	Sample Location	Initial D/T x m3/sec	Final Endpoint
23	Solids Scrubber Exhaust 2	24001.20	1.00
16	Solids Scrubber Exhaust 1	13806.00	1.00
11	EQ Basin - 20 ft.	35413.59	1.00
29	Total Aeration 2	28950.24	1.00
20	EQ Basin - 14 ft.	24620.88	1.00
18	Total Primaries	19755.44	1.00
26	Aeration Basin Influent (2)	16564.57	1.00
4	Primary Clarifier Weir 1	14785.87	1.00
17	Headworks Scrubber Exhaust	2336.40	1.00
27	Aeration Basin Midpoint (2)	6696.32	1.00
19	Total Aeration 1	6559.43	1.00
28	Aeration Basin End (2)	5689.35	1.00
21	Dry Creek Lift Station	1352.28	1.00
6	Aeration Basin Influent (1)	4380.30	1.00
1	Primary Channel Influent	3410.20	1.00
7	Aeration Basin Midpoint (1)	1309.05	1.00
22	Primaries w/o Weir Area	1262.38	1.00
8	Aeration Basin End (1)	704.88	1.00
5	Primary Effluent Channel	623.04	1.00
2	Primary Clarifier Influent	588.94	1.00
25	Primary Clarifier Weir 2	542.80	1.00
3	Primary Clarifier Midpoint	347.39	1.00
9	Mixed Liquor Channel	165.20	1.00
10	Final Clarifier	97.37	1.00
24	Primary Clarifier Midpoint (2)	40.71	1.00
12	Dewatered Sludge w/Permanganate	7.77	1.00
13	Dewatered Sludge w/o Permanganate	5.56	1.00
14	Dewatering Bldg. w/ Permanganate	0.00	1.00
15	Dewatering Bldg. w/o Permanganate	0.00	1.00

Table 11
Average Transport Distances

Nashville - Dry Creek

		Stability Class 6						Stability Class 4					
		1 m/s		2 m/s		4 m/s		1 m/s		2 m/s		4 m/s	
Location	**Allowable**	**Max/Dist**	**1**	**Max/Dist**	**1**	**Max/Dist**	**1**	**Max/Dist**	**1**	**Max/Dist**	**1**	**Max/Dist**	**1**
Solids Scrubber Exhaust 2	0.410	.775/1423	650	.564/1813	650	.398/941	-	.18/1321	-	.32/706	-	.44/394	500
Solids Scrubber Exhaust 1	0.873	.45/1423	-	.32/1119	-	.23/941	-	.1/1041	-	NR	NR	NR	NR
EQ Basin - 20 ft.	0.140	4.08/174	>2000	2.04/174	>2000	1.02/174	>2000	3.94/103	>2000	2.0/103	1410	.984/103	890
Total Aeration 2	0.845	8.3/95	1620	4.1/95	920	2.1/95	520	7.5/67	630	3.8/67	380	1.9/67	220
EQ Basin - 14 ft.	0.729	2.8/174	1490	1.4/174	790	.71/174	-	2.7/103	580	1.4/103	350	.68/103	-
Total Primaries	0.736	7.45/85	>2000	3.72/85	>2000	1.86/85	1750	6.98/56	>2000	3.5/56	650	1.75/56	620
Aeration Basin Influent (2)	0.885	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
Primary Clarifier Weir 1	0.432	9.4/69	>2000	4.7/69	>2000	2.3/69	1750	9.1/41	>2000	4.5/41	650	2.3/41	620
Headworks Scrubber Exhaust	0.514	.547/440	350	.37/355	-	NR	NR	.41/440	-	NR	NR	NR	NR
Aeration Basin Midpoint (2)	0.519	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
Total Aeration 1	0.895	1.88/95	450	.94/95	120	.47/95	-	1.7/67	150	.852/67	-	.43/67	-
Aeration Basin End (2)	0.885	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
Dry Creek Lift Station	1.016	.244/504	-	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
Aeration Basin Influent (1)	0.167	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
Primary Channel Influent	0.582	3.4/60	350	1.7/60	200	.86/60	80	3.3/32	250	1.69/32	180	.845/32	50
Aeration Basin Midpoint (1)	0.055	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
Primaries w/o Weir Area	1.046	.46/132	-	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
Aeration Basin End (1)	0.310	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
Primary Effluent Channel	1.758	.59/61	-	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
Primary Clarifier Influent	1.030	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
Primary Clarifier Weir 2	0.662	.34/69	-	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
Primary Clarifier Midpoint	1.261	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
Mixed Liquor Channel	0.000	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
Final Clarifier	0.503	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
Primary Clarifier Midpoint (2)	0.774	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
Dewatered Sludge w/Permanganate	0.774	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
Dewatered Sludge w/o Permanganate	0.715	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
Dewatering Bldg. w/ Permanganate	0.855	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
Dewatering Bldg. w/o Permanganate	0.852	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR

Table 12
Peak Transport Distances
Nashville - Dry Creek

			Stability Class 6									Stability Class 4								
			1 m/s			2 m/s			4 m/s			1 m/s			2 m/s			4 m/s		
Location	**Allowable**	**Allowable**	**Max/Dist**	**1**	**5**	**Max/Dist**	**1**	**5**	**Max/Dist**	**1**	**5**	**Max/Dist**	**1**	**5**	**Max/Dist**	**1**	**5**	**Max/Dist**	**1**	**5**
Solids Scrubber Exhaust 2	1	5	2.3/1423	>2000	-	1.69/1119	>2000	-	1.19/941	1500	-	.54/1321	-	-	.96/706	-	-	1.33/394	650	-
Solids Scrubber Exhaust 1	1	5	1.34/1421	>2000	-	.97/1119	-	-	NR	NR	NR	.31/1321	-	-	NR	NR	NR	NR	NR	NR
EQ Basin - 20 ft.	1	5	41/174	>2000	>2000	20.5/174	>2000	1550	10.2/174	>2000	870	39.5/173	>2000	580	19.8/103	1800	600	9.9/103	1120	350
Total Aeration 2	1	5	24.9/95	>2000	980	12.5/95	1900	520	6.2/95	1110	2220	22.6/67	1100	300	11.3/67	690	220	5.6/67	450	80
EQ Basin - 14 ft.	1	5	28.4/174	>2000	1910	14.2/174	>2000	1150	7.1/174	>2000	520	27.4/103	>2000	160	13.7/103	1400	470	6.8/103	850	250
Total Primaries	1	5	74.5/85	>2000	1850	37.2/85	>2000	1110	18.6/85	>2000	750	69.8/56	1910	690	34.9/56	1210	450	17.5/56	800	280
Aeration Basin Influent (2)	1	5	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
Primary Clarifier Weir 1	1	5	93.7/69	>2000	1490	46.8/69	>2000	950	23.4/69	1750	590	91.0/41	1620	600	45.4/41	1010	380	22.7/41	680	250
Headworks Scrubber Exhaust	1	5	1.6/440	1000	-	1.1/355	400	-	1.0/208	-	-	1.2/440	350	-	1.3/152	100	-	NR	NR	NR
Aeration Basin Midpoint (2)	1	5	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
Total Aeration 1	1	5	18.3/95	>2000	750	9.4/95	1510	380	4.7/95	910	-	17/67	910	320	8.5/67	610	150	4.3/67	380	-
Aeration Basin End (2)	1	5	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
Dry Creek Lift Station	1	5	.73/504	-	-	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
Aeration Basin Influent (1)	1	5	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
Primary Channel Influent	1	5	34.4/60	1690	580	17.2/60	1050	350	8.6/60	650	200	33.8/32	650	250	16.9/32	420	180	8.44/32	280	80
Aeration Basin Midpoint (1)	1	5	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
Primaries w/o Weir Area	1	5	4.6/132	810	-	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
Aeration Basin End (1)	1	5	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
Primary Effluent Channel	1	5	5.9/61	520	120	2.9/61	310	-	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
Primary Clarifier Influent	1	5	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
Primary Clarifier Weir 2	1	5	3.4/69	450	-	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
Primary Clarifier Midpoint	1	5	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
Mixed Liquor Channel	1	5	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
Final Clarifier	1	5	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
Primary Clarifier Midpoint (2)	1	5	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
Dewatered Sludge w/Permanganate	1	5	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
Dewatered Sludge w/o Permanganate	1	5	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
Dewatering Bldg. w/ Permanganate	1	5	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
Dewatering Bldg. w/o Permanganate	1	5	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR

Table 13
Required Percent Removals (Average)
Nashville - Dry Creek

Sample #	Location	Distance (Feet)	Initial OER	Des. Endpoints 5	Des. Endpoints 1	Final OER 5	Final OER 1	Required % Removal 5	Required % Removal 1
23	Solids Scrubber Exhaust 2	500	8000.40	2.050	0.410	8000.4	4250	0%	47%
16	Solids Scrubber Exhaust 1	500	BT	BT	BT			0%	0%
11	EQ Basin - 20 ft.	300	3541.36	0.699	0.140	600	120	83%	97%
29	Total Aeration 2	300	2895.02	4.227	0.845	1500	300	48%	90%
20	EQ Basin - 14 ft.	300	2462.09	3.647	0.729	2462.1	625	0%	75%
18	Total Primaries	100	1975.54	3.682	0.736	950	195	52%	90%
26	Aeration Basin Influent (2)	100	NR	NR	NR			NR	NR
4	Primary Clarifier Weir 1	100	1478.59	2.160	0.432	340	68	77%	95%
17	Headworks Scrubber Exhaust	200	778.80	2.570	0.514	778.8	700	0%	10%
27	Aeration Basin Midpoint (2)	300	NR	NR	NR			NR	NR
19	Total Aeration 1	300	655.94	0.823	0.165	285	75	57%	89%
28	Aeration Basin End (2)	300	NR	NR	NR			NR	NR
21	Dry Creek Lift Station	300	BT	BT	BT			0%	0%
6	Aeration Basin Influent (1)	200	NR	NR	NR			NR	NR
1	Primary Channel Influent	200	341.02	2.911	0.582	290	60	15%	82%
7	Aeration Basin Midpoint (1)	300	NR	NR	NR			NR	NR
22	Primaries w/o Weir Area	100	BT	BT	BT			0%	0%
8	Aeration Basin End (1)	300	NR	NR	NR			NR	NR
5	Primary Effluent Channel	150	BT	BT	BT			0%	0%
2	Primary Clarifier Influent	50	NR	NR	NR			NR	NR
25	Primary Clarifier Weir 2	100	BT	BT	BT			0%	0%
3	Primary Clarifier Midpoint	100	NR	NR	NR			NR	NR
9	Mixed Liquor Channel	400	NR	NR	NR			NR	NR
10	Final Clarifier	400	NR	NR	NR			NR	NR
24	Primary Clarifier Midpoint (2)		NR	NR	NR			NR	NR
12	Dewatered Sludge w/Permanganate		NR	NR	NR			NR	NR
13	Dewatered Sludge w/o Permanganate		NR	NR	NR			NR	NR
14	Dewatering Bldg. w/ Permanganate		NR	NR	NR			NR	NR
15	Dewatering Bldg. w/o Permanganate		NR	NR	NR			NR	NR

Table 14
Required % Removals (Peak)

Nashville - Dry Creek

Sample #	Location	Distance (Feet)	Initial OER	Design Endpoints	Final OER	Required % Removal
23	Solids Scrubber Exhaust 2	500	24001.20	1	10500	56%
16	Solids Scrubber Exhaust 1	500	13806.00	1	10500	24%
11	EQ Basin - 20 ft.	300	35413.59	1	870	98%
29	Total Aeration 2	300	28950.24	1	350	99%
20	EQ Basin - 14 ft.	300	24620.88	1	880	96%
18	Total Primaries	100	19755.44	1	265	99%
26	Aeration Basin Influent (2)	100	NR	1		NR
4	Primary Clarifier Weir 1	100	14785.87	1	160	99%
17	Headworks Scrubber Exhaust	200	2336.40	1	1400	40%
27	Aeration Basin Midpoint (2)	300	NR	1		NR
19	Total Aeration 1	300	6559.43	1	350	95%
28	Aeration Basin End (2)	300	NR	1		NR
21	Dry Creek Lift Station	300	BT	1	-	0%
6	Aeration Basin Influent (1)	200	NR	1		NR
1	Primary Channel Influent	200	3410.20	1	100	97%
7	Aeration Basin Midpoint (1)	300	NR	1		NR
22	Primaries w/o Weir Area	100	1262.38	1	275	78%
8	Aeration Basin End (1)	300	NR	1		NR
5	Primary Effluent Channel	150	623.04	1	105	83%
2	Primary Clarifier Influent	50	NR	1		NR
25	Primary Clarifier Weir 2	100	542.80	1	157	71%
3	Primary Clarifier Midpoint	100	NR	1		NR
9	Mixed Liquor Channel	400	NR	1		NR
10	Final Clarifier	400	NR	1		NR
24	Primary Clarifier Midpoint (2)		NR	1		NR
12	Dewatered Sludge w/Permanganate		NR	1		NR
13	Dewatered Sludge w/o Permanganate		NR	1		NR
14	Dewatering Bldg. w/ Permanganate		NR	1		NR
15	Dewatering Bldg. w/o Permanganate		NR	1		NR

Table 15
Priority Odor Sources
Class 1

Nashville - Dry Creek

Rank	Class 1 Sources Average	Rank	Class 1 Sources Peak
1	EQ Basin - 20 ft.	1	EQ Basin - 20 ft.
2	Total Primaries	2	EQ Basin - 14 ft.
3	Primary Clarifier Weir 1	3	Total Primaries
4	Total Aeration 2	4	Primary Clarifier Weir 1
5	EQ Basin - 14 ft.	5	Total Aeration 2
6	Solids Scrubber Exhaust 2	6	Total Aeration 1
7	Total Aeration 1	7	Primary Channel Influent
8	Headworks Scrubber Exhaust	8	Primary Effluent Channel
9	Primary Channel Influent		

Table 16
Priority of Odor Sources
Class 2

Nashville - Dry Creek

Solids Scrubber Exhaust 1
Total Primaries
Total Aeration 2
Aeration Basin Influent (2)
Primary Channel Influent
Aeration Basin Midpoint (2)
Dry Creek Lift Station
Aeration Basin End (2)
Aeration Basin Influent (1)
Total Aeration 1
Primaries w/o Weir Area
Solids Scrubber Exhaust 2
EQ Basin - 20 ft.
EQ Basin - 14 ft.
Primary Clarifier Weir 1
Headworks Scrubber Exhaust
Dewatering Bldg. w/o Permanganate

Odor Logs

Dry Creek WWTP GPS Data
K Harrison
6/14/2002

Reference	Location	N	W
1	Center Grit Chambers	36 17.345	086 41.417
2	Center Influent Channel at end of Grit Chamber	36 17.342	086 41.398
3	Influent Channel at 90 turn	36 17.340	086 41.397
4	Influent Scrubber Stack	36 17.341	086 41.412
5	Influent Channel at Equipment Building	36 17.353	086 41.355
6	Primary Clarifier #1 Influent End	36 17.365	086 41.322
7	Primary Clarifier #2 Influent End	36 17.368	086 41.315
8	Primary Clarifier #3 Influent End	36 17.374	086 41.326
9	Primary Clarifier #4 Influent End	36 17.377	086 41.319
10	Primary Clarifier #5 Influent End	36 17.371	086 41.306
11	Primary Clarifier #6 Influent End	36 17.374	086 41.299
12	Primary Clarifier #7 Influent End	36 17.379	086 41.310
13	Primary Clarifier #8 Influent End	36 17.381	086 41.302
14	Primary Clarifier #1 Effluent End	36 17.353	086 41.317
15	Primary Clarifier #2 Effluent End	36 17.356	086 41.310
16	Primary Clarifier #3 Effluent End	36 17.391	086 41.334
17	Primary Clarifier #4 Effluent End	36 17.393	086 41.326
18	Primary Clarifier #5 Effluent End	36 17.357	086 41.301
19	Primary Clarifier #6 Effluent End	36 17.359	086 41.294
20	Primary Clarifier #7 Effluent End	36 17.395	086 41.318
21	Primary Clarifier #8 Effluent End	36 17.397	086 41.310
22	Effluent Flume near #8	36 17.398	086 41.313
23	Effluent Flume near #6	36 17.357	086 41.296
24	Effluent Flume near #2	36 17.354	086 41.312
25	Effluent Flume near #4	36 17.393	086 41.330
26	Aeration Basin 1-1 West End	36 17.348	086 41.315
27	Aeration Basin 1-2 West End	36 17.344	086 41.314
28	Aeration Basin 1-3 West End	36 17.340	086 41.312
29	Aeration Basin 1-4 West End	36 17.337	086 41.311
30	Aeration Basin 2-1 West End	36 17.333	086 41.309
31	Aeration Basin 2-2 West End	36 17.329	086 41.307
32	Aeration Basin 2-3 West End	36 17.325	086 41.305
33	Aeration Basin 2-4 West End	36 17.312	086 41.304
34	Aeration Basin 3-1 West End	36 17.317	086 41.302
35	Aeration Basin 3-2 West End	36 17.313	086 41.301
36	Aeration Basin 3-3 West End	36 17.309	086 41.298
37	Aeration Basin 3-4 West End	36 17.305	086 41.297
38	Aeration Basin 1-1 East End	36 17.361	086 41.276
39	Aeration Basin 1-2 East End	36 17.357	086 41.274
40	Aeration Basin 1-3 East End	36 17.353	086 41.272
41	Aeration Basin 1-4 East End	36 17.349	086 41.270
42	Aeration Basin 2-1 East End	36 17.345	086 41.269
43	Aeration Basin 2-2 East End	36 17.341	086 41.267
44	Aeration Basin 2-3 East End	36 17.337	086 41.265
45	Aeration Basin 2-4 East End	36 17.333	086 41.263
46	Aeration Basin 3-1 East End	36 17.329	086 41.262
47	Aeration Basin 3-2 East End	36 17.325	086 41.260

48	Aeration Basin 3-3 East End	36 17.321	086 41.257
49	Aeration Basin 3-4 East End	36 17.317	086 41.255
50	Final Clarifier #7 Center	36 17.290	086 41.291
51	Final Clarifier #8 Center	36 17.299	086 41.265
52	Final Clarifier #9 Center	36 17.269	086 41.279
53	Aeration Basin Efflunet Channel Between FC #7 & #8	36 17.307	086 41.281
54	Aeration Basin Effluent Channel at 90 turn	36 17.302	086 41.301
55	Aeration Basin Effluent Channel at North end	36 17.344	086 41.321
56	Final Clarifier #1 Center	36 17.336	086 41.337
57	Final Clarifier #2 Center	36 17.320	086 41.329
58	Final Clarifier #3 Center	36 17.332	086 41.353
59	Final Clarifier #4 Center	36 17.316	086 41.345
60	Final Clarifier #5 Center	36 17.327	086 41.368
61	Final Clarifier #6 Center	36 17.311	086 41.360
62	Final Clarifer Effluent Channel between #1 & #2	36 17.329	086 41.332
63	Final Claifier Effluent Channel west end	36 17.320	086 41.359
64	Pump Station Scrubber Stack	36 17.289	086 41.359
65	Sludge Building Scrubber Stack	36 17.300	086 41.380
66	Sludge Loading Chute	36 17.317	086 41.414
67	EQ Basin NW Corner	36 17.294	086 41.503
68	EQ Basin NE Corner	36 17.311	086 41.444
69	EQ Basin SW Corner	36 17.247	086 41.483
70	EQ Basin SE Corner	36 17.288	086 41.424
71	EQ Basin Center	36 17.280	086 41.464

Dry Creek WWTP Odor Log Data
K. Harrison
6/14/2002

Date	Time	Location	N	W
10/10/2001	6:30 AM	1903 Spring Branch Rd	36 17.703	086 41.528
10/10/2001	6:45 AM	Myatt Drive at bridge	36 17.320	086 41.599
10/10/2001	7:30 AM	Myatt Drive at bridge	36 17.320	086 41.599
10/11/2001	6:35 AM	1903 Spring Branch Rd	36 17.703	086 41.528
10/11/2001	6:45 AM	Myatt Drive at bridge	36 17.320	086 41.599
10/11/2001	5:30 PM	Myatt Drive at bridge	36 17.320	086 41.599
10/11/2001	5:45 PM	1903 Spring Branch Rd	36 17.703	086 41.528
10/17/2001	6:45 AM	Myatt Drive at bridge	36 17.320	086 41.599
10/17/2001	9:05 AM	1217 Northgate Business Pkwy	36 17.151	086 41.385
10/17/2001	5:45 PM	1903 Spring Branch Rd	36 17.703	086 41.528
10/18/2001	7:00 PM	1903 Spring Branch Rd	36 17.703	086 41.528
10/19/2001	7:00 AM	1903 Spring Branch Rd	36 17.703	086 41.528
10/20/2001	6:45 AM	1903 Spring Branch Rd	36 17.703	086 41.528
10/23/2001	5:30 PM	1903 Spring Branch Rd	36 17.703	086 41.528
10/24/2001	6:45 AM	1903 Spring Branch Rd	36 17.703	086 41.528
10/25/2001	6:45 AM	1903 Spring Branch Rd	36 17.703	086 41.528
10/26/2001	6:30 AM	1903 Spring Branch Rd	36 17.703	086 41.528
10/27/2001	6:00 PM	1903 Spring Branch Rd	36 17.703	086 41.528
10/28/2001	5:50 PM	1903 Spring Branch Rd	36 17.703	086 41.528
10/29/2001	6:45 AM	1903 Spring Branch Rd	36 17.703	086 41.528
10/29/2001	10:15 AM	2105 East Hill Dr	36 17.775	086 41.075
10/29/2001	6:00 PM	1217 Northgate Business Pkwy	36 17.151	086 41.385
10/30/2001	4:45 PM	1903 Spring Branch Rd	36 17.703	086 41.528
10/31/2001	7:30 AM	1217 Northgate Business Pkwy	36 17.151	086 41.385
10/31/2001	5:30 PM	1903 Spring Branch Rd	36 17.703	086 41.528
10/31/2001	8:00 PM	2105 East Hill Dr	36 17.775	086 41.075
11/1/2001	6:45 AM	1903 Spring Branch Rd	36 17.703	086 41.528
11/1/2001	10:00 AM	2105 East Hill Dr	36 17.775	086 41.075
11/2/2001	9:55 AM	2105 East Hill Dr	36 17.775	086 41.075
11/2/2001	3:45 PM	2105 East Hill Dr	36 17.775	086 41.075
11/2/2001	5:15 PM	1903 Spring Branch Rd	36 17.703	086 41.528
11/4/2001	8:00 PM	1903 Spring Branch Rd	36 17.703	086 41.528
11/8/2001	6:20 PM	2105 East Hill Dr	36 17.775	086 41.075
11/8/2001	8:00 PM	1903 Spring Branch Rd	36 17.703	086 41.528
11/10/2001	9:00 AM	Myatt Dr At Dollar General	36 16.586	086 41.362
11/14/2001	6:00 PM	1903 Spring Branch Rd	36 17.703	086 41.528
11/14/2001	7:45 PM	2105 East Hill Dr	36 17.775	086 41.075
11/21/2001	5:45 PM	1903 Spring Branch Rd	36 17.703	086 41.528
11/22/2001	12:00 PM	1903 Spring Branch Rd	36 17.703	086 41.528
11/22/2001	8:00 PM	1903 Spring Branch Rd	36 17.703	086 41.528
12/2/2001	7:40 PM	2105 East Hill Dr	36 17.775	086 41.075

Table 1
Odor Occurrence Vector Program
Source and Receptor Information
Nashville - Dry Creek

Client	Metro Water Services				
Facility	Nashville - Dry Creek	**Final D/T**	0.5		
Date of Run	4/29/2003	**Deviations**	Less	Greater	
		Wind Speed (m/s)	5	5	
		Vectors	40	10	
		Source Vector Deviation	5		
Source Information (Maximum of 20)		Source Distance Deviation	500		
Number of Sources	19				

	Source	Lat.		Long.		OER Initial	OER Final	Dilutions
1	Influent Channel - HW	36	17.340	86	41.397	289	0.50	578
2	Grit Scrubber	36	17.341	86	41.412	380	0.50	760
3	Influent Channel -Mid	36	17.353	86	41.355	289	0.50	578
4	Pri. Clarifier #3 Inf.	36	17.374	86	41.326	217	0.50	434
5	Pri. Clarifier #7 Inf.	36	17.379	86	41.310	217	0.50	434
6	Pri. Clarifier #3 Eff.	36	17.391	86	41.334	44	0.50	88
7	Pri. Clarifier #7 Eff.	36	17.395	86	41.318	44	0.50	88
8	Flume Near Pri. #6	36	17.357	86	41.296	1362	0.50	2724
9	Flume Near Pri. #4	36	17.393	86	41.330	1362	0.50	2724
10	Aeration Basin 1-1 West	36	17.348	86	41.315	87	0.50	174
11	Aeration Basin 2-1 West	36	17.333	86	41.309	87	0.50	174
12	Aeration Basin 3-1 West	36	17.317	86	41.302	87	0.50	174
13	Aeration Basin 1-1 East	36	17.361	86	41.276	87	0.50	174
14	Aeration Basin 2-1 East	36	17.345	86	41.269	87	0.50	174
15	Aeration Basin 3-1 East	36	17.329	86	41.262	87	0.50	174
16	Pump Station Scrubber	36	17.289	86	41.359	191	0.50	382
17	Solids Building Scrubber	36	17.3	86	41.38	325	0.50	650
18	Sludge Loading Chute	36	17.317	86	41.414	1447	0.50	2894
19	EQ Basin	36	17.28	86	41.464	840	0.50	1680

Receptor Information (Maximum of 20)

Number of Receptors 5

	Receptor	Lat		Long.	
1	1903 Spring Branch Rd	36	17.703	86	41.528
2	Myatt Dr. at Bridge	36	17.320	86	41.599
3	1217 Northgate Bus. Pkw	36	17.151	86	41.385
4	2105 East Hill Dr	36	17.775	86	41.075
5	Myatt Dr at Dollar Gen	36	16.586	86	41.362

Table 2
Odor Occurrence Vector Program
Vectors and Distances

Nashville - Dry Creek

Vectors and Distances

From	Receptor	Source	To	Distance Meters	Vector
1	1	Influent Channel - HW	1903 Spring Branch Rd	700.14	343.78
2	1	Grit Scrubber	1903 Spring Branch Rd	692.42	345.52
3	1	Influent Channel -Mid	1903 Spring Branch Rd	697.75	338.28
4	1	Pri. Clarifier #3 Inf.	1903 Spring Branch Rd	679.84	333.67
5	1	Pri. Clarifier #7 Inf.	1903 Spring Branch Rd	682.61	331.53
6	1	Pri. Clarifier #3 Eff.	1903 Spring Branch Rd	646.33	333.38
7	1	Pri. Clarifier #7 Eff.	1903 Spring Branch Rd	650.88	331.21
8	1	Flume Near Pri. #6	1903 Spring Branch Rd	728.39	331.61
9	1	Flume Near Pri. #4	1903 Spring Branch Rd	645.73	332.76
10	1	Aeration Basin 1-1 West	1903 Spring Branch Rd	730.31	334.19
11	1	Aeration Basin 2-1 West	1903 Spring Branch Rd	759.23	334.50
12	1	Aeration Basin 3-1 West	1903 Spring Branch Rd	790.48	334.74
13	1	Aeration Basin 1-1 East	1903 Spring Branch Rd	736.67	329.30
14	1	Aeration Basin 2-1 East	1903 Spring Branch Rd	767.50	329.75
15	1	Aeration Basin 3-1 East	1903 Spring Branch Rd	798.39	330.18
16	1	Pump Station Scrubber	1903 Spring Branch Rd	807.16	341.79
17	1	Solids Building Scrubber	1903 Spring Branch Rd	778.37	343.51
18	1	Sludge Loading Chute	1903 Spring Branch Rd	734.85	346.61
19	1	EQ Basin	1903 Spring Branch Rd	789.20	353.05
1	2	Influent Channel - HW	Myatt Dr. at Bridge	303.81	263.00
2	2	Grit Scrubber	Myatt Dr. at Bridge	281.85	262.07
3	2	Influent Channel -Mid	Myatt Dr. at Bridge	369.33	260.48
4	2	Pri. Clarifier #3 Inf.	Myatt Dr. at Bridge	419.62	256.21
5	2	Pri. Clarifier #7 Inf.	Myatt Dr. at Bridge	445.04	255.79
6	2	Pri. Clarifier #3 Eff.	Myatt Dr. at Bridge	416.87	251.61
7	2	Pri. Clarifier #7 Eff.	Myatt Dr. at Bridge	441.87	251.68
8	2	Flume Near Pri. #6	Myatt Dr. at Bridge	457.48	261.39
9	2	Flume Near Pri. #4	Myatt Dr. at Bridge	423.71	251.39
10	2	Aeration Basin 1-1 West	Myatt Dr. at Bridge	427.11	263.03
11	2	Aeration Basin 2-1 West	Myatt Dr. at Bridge	433.58	266.82
12	2	Aeration Basin 3-1 West	Myatt Dr. at Bridge	443.39	270.72
13	2	Aeration Basin 1-1 East	Myatt Dr. at Bridge	488.11	261.05
14	2	Aeration Basin 2-1 East	Myatt Dr. at Bridge	494.79	264.63
15	2	Aeration Basin 3-1 East	Myatt Dr. at Bridge	503.35	268.10
16	2	Pump Station Scrubber	Myatt Dr. at Bridge	362.84	279.11
17	2	Solids Building Scrubber	Myatt Dr. at Bridge	329.01	276.47
18	2	Sludge Loading Chute	Myatt Dr. at Bridge	276.22	271.15
19	2	EQ Basin	Myatt Dr. at Bridge	214.71	290.18
1	3	Influent Channel - HW	1217 Northgate Bus. Pkw	350.49	177.07
2	3	Grit Scrubber	1217 Northgate Bus. Pkw	354.18	173.46
3	3	Influent Channel -Mid	1217 Northgate Bus. Pkw	376.78	186.83
4	3	Pri. Clarifier #3 Inf.	1217 Northgate Bus. Pkw	422.28	192.04
5	3	Pri. Clarifier #7 Inf.	1217 Northgate Bus. Pkw	436.85	194.85
6	3	Pri. Clarifier #3 Eff.	1217 Northgate Bus. Pkw	450.95	189.72
7	3	Pri. Clarifier #7 Eff.	1217 Northgate Bus. Pkw	462.82	192.48
8	3	Flume Near Pri. #6	1217 Northgate Bus. Pkw	403.98	199.20
9	3	Flume Near Pri. #4	1217 Northgate Bus. Pkw	455.64	190.38
10	3	Aeration Basin 1-1 West	1217 Northgate Bus. Pkw	379.51	195.98
11	3	Aeration Basin 2-1 West	1217 Northgate Bus. Pkw	355.65	198.60
12	3	Aeration Basin 3-1 West	1217 Northgate Bus. Pkw	331.46	201.95
13	3	Aeration Basin 1-1 East	1217 Northgate Bus. Pkw	421.59	202.70
14	3	Aeration Basin 2-1 East	1217 Northgate Bus. Pkw	398.84	205.73

Receptor	Directional Range Average	Min	Max
1	337	329	353
2	264	251	290
3	190	154	209
4	26	19	32
5	181	173	186

Table 2
Odor Occurrence Vector Program
Vectors and Distances

15	3	Aeration Basin 3-1 East	1217 Northgate Bus. Pkw	377.34	209.12

Table 2
Odor Occurrence Vector Program
Vectors and Distances

Vectors and Distances				Distance	
From	Receptor	Source	To	Meters	Vector
16	3	Pump Station Scrubber	1217 Northgate Bus. Pkw	258.51	188.64
17	3	Solids Building Scrubber	1217 Northgate Bus. Pkw	276.05	181.55
18	3	Sludge Loading Chute	1217 Northgate Bus. Pkw	310.47	171.98
19	3	EQ Basin	1217 Northgate Bus. Pkw	266.43	153.73
1	4	Influent Channel - HW	2105 East Hill Dr	938.11	30.82
2	4	Grit Scrubber	2105 East Hill Dr	948.21	32.04
3	4	Influent Channel -Mid	2105 East Hill Dr	886.29	28.14
4	4	Pri. Clarifier #3 Inf.	2105 East Hill Dr	831.81	26.77
5	4	Pri. Clarifier #7 Inf.	2105 East Hill Dr	812.97	25.56
6	4	Pri. Clarifier #3 Eff.	2105 East Hill Dr	809.46	28.53
7	4	Pri. Clarifier #7 Eff.	2105 East Hill Dr	791.74	27.27
8	4	Flume Near Pri. #6	2105 East Hill Dr	841.50	23.08
9	4	Flume Near Pri. #4	2105 East Hill Dr	803.36	28.28
10	4	Aeration Basin 1-1 West	2105 East Hill Dr	868.17	24.37
11	4	Aeration Basin 2-1 West	2105 East Hill Dr	889.99	23.11
12	4	Aeration Basin 3-1 West	2105 East Hill Dr	913.39	21.77
13	4	Aeration Basin 1-1 East	2105 East Hill Dr	823.34	21.37
14	4	Aeration Basin 2-1 East	2105 East Hill Dr	847.38	19.98
15	4	Aeration Basin 3-1 East	2105 East Hill Dr	871.88	18.67
16	4	Pump Station Scrubber	2105 East Hill Dr	994.91	25.22
17	4	Solids Building Scrubber	2105 East Hill Dr	990.53	27.36
18	4	Sludge Loading Chute	2105 East Hill Dr	987.69	30.82
19	4	EQ Basin	2105 East Hill Dr	1085.17	32.35
1	5	Influent Channel - HW	Myatt Dr at Dollar Gen	1397.39	177.86
2	5	Grit Scrubber	Myatt Dr at Dollar Gen	1400.25	176.94
3	5	Influent Channel -Mid	Myatt Dr at Dollar Gen	1420.52	180.42
4	5	Pri. Clarifier #3 Inf.	Myatt Dr at Dollar Gen	1460.37	182.11
5	5	Pri. Clarifier #7 Inf.	Myatt Dr at Dollar Gen	1470.69	183.03
6	5	Pri. Clarifier #3 Eff.	Myatt Dr at Dollar Gen	1491.45	181.61
7	5	Pri. Clarifier #7 Eff.	Myatt Dr at Dollar Gen	1499.71	182.51
8	5	Flume Near Pri. #6	Myatt Dr at Dollar Gen	1431.29	183.95
9	5	Flume Near Pri. #4	Myatt Dr at Dollar Gen	1495.33	181.83
10	5	Aeration Basin 1-1 West	Myatt Dr at Dollar Gen	1412.97	182.85
11	5	Aeration Basin 2-1 West	Myatt Dr at Dollar Gen	1385.70	183.27
12	5	Aeration Basin 3-1 West	Myatt Dr at Dollar Gen	1356.77	183.79
13	5	Aeration Basin 1-1 East	Myatt Dr at Dollar Gen	1441.03	185.11
14	5	Aeration Basin 2-1 East	Myatt Dr at Dollar Gen	1412.51	185.64
15	5	Aeration Basin 3-1 East	Myatt Dr at Dollar Gen	1384.11	186.19
16	5	Pump Station Scrubber	Myatt Dr at Dollar Gen	1301.96	180.20
17	5	Solids Building Scrubber	Myatt Dr at Dollar Gen	1322.60	178.84
18	5	Sludge Loading Chute	Myatt Dr at Dollar Gen	1356.04	176.72
19	5	EQ Basin	Myatt Dr at Dollar Gen	1294.28	173.24

Table 3
Odor Occurrence Vector Program
Event Information
Nashville - Dry Creek

Receptor #	Number of Events	
1	24	24
2	5	29
3	3	32
4	8	40
5	1	41
Total	**41**	

Event Number	Receptor	Date	Time	Wind Dir	Wind Speed Kts	M/S	Cloud Cov	Temp	Temp	Ceiling	Final Stability	Dir. Prob.	Dir Range	
1	1	10/10/2001	630	150	4	2.06	0.8	57	14	20000	6	Random	Random	Random
2	1	10/11/2001	635	180	7	3.60	0.8	65	18	6500	6	Random	Random	Random
3	1	10/11/2001	1745	140	6	3.09	0.8	68	20	12000	4	140	100	180
4	1	10/17/2001	1745	10	4	2.06	0.1	53	12	20000	4	10	330	50
5	1	10/18/2001	1900	170	6	3.09	0.8	56	13	25000	4	170	130	210
6	1	10/19/2001	700	180	3	1.54	0.8	49	9	25000	6	Random	Random	Random
7	1	10/20/2001	645	170	4	2.06	0	45	7	40000	7	Random	Random	Random
8	1	10/23/2001	1730	190	6	3.09	1	74	23	25000	6	Random	Random	Random
9	1	10/24/2001	645	210	9	4.63	1	70	21	7000	4	210	170	250
10	1	10/25/2001	645	240	3	1.54	0	50	10	40000	7	Random	Random	Random
11	1	10/26/2001	630	260	10	5.14	0	46	8	40000	7	Random	Random	Random
12	1	10/27/2001	1800	360	5	2.57	0	44	7	40000	4	360	320	680
13	1	10/28/2001	1750	50	3	1.54	0.1	49	9	25000	4	50	10	90
14	1	10/29/2001	645	30	4	2.06	0	52	11	40000	7	Random	Random	Random
15	1	10/30/2001	1645	360	0	0.00	0.3	64	18	25000	4	Random	Random	Random
16	1	10/31/2001	1730	170	5	2.57	0.8	59	15	25000	4	170	130	210
17	1	11/1/2001	645	180	7	3.60	0.3	56	13	25000	7	Random	Random	Random
18	1	11/2/2001	1715	360	0	0.00	0.8	75	24	9500	4	Random	Random	Random
19	1	11/4/2001	2000	350	3	1.54	0	65	18	40000	4	350	310	670
20	1	11/8/2001	2000	360	5	2.57	0.3	62	17	25000	4	360	320	680
21	1	11/14/2001	1800	50	4	2.06	0	59	15	40000	4	50	10	90
22	1	11/21/2001	1745	190	4	2.06	0.2	50	10	20000	4	190	150	230
23	1	11/22/2001	1200	200	7	3.60	0.8	57	14	15000	4	200	160	240
24	1	11/22/2001	2000	150	5	2.57	1	50	10	10000	7	Random	Random	Random
25	2	10/10/2001	645	150	4	2.06	0.8	57	14	20000	6	Random	Random	Random

Table 3
Odor Occurrence Vector Program
Event Information

Event					Wind Speed									
Number	Receptor	Date	Time	Wind Dir	Kts	M/S	Cloud Cov	Temp	Temp	Ceiling	Final Stability	Dir. Prob.	Dir Range	
26	2	10/10/2001	730	180	12	6.17	0.3	63	17	25000	7	Random	Random	Random
27	2	10/11/2001	645	180	7	3.60	0.8	65	18	6500	6	Random	Random	Random
28	2	10/11/2001	1730	140	6	3.09	1	68	20	12000	6	Random	Random	Random
29	2	10/17/2001	645	260	4	2.06	0	39	4	40000	7	Random	Random	Random
30	3	10/17/2001	905	300	4	2.06	0	48	9	40000	4	300	260	340
31	3	10/29/2001	1800	160	3	1.54	0	58	14	40000	4	160	120	200
32	3	10/31/2001	730	360	0	0.00	0.2	47	8	20000	7	Random	Random	Random
33	4	10/29/2001	1015	170	8	4.12	0	57	14	40000	4	170	130	210
34	4	10/31/2001	2000	180	8	4.12	0.8	56	13	25000	4	180	140	220
35	4	11/1/2001	1000	190	12	6.17	0.8	69	21	20000	4	190	180	200
36	4	11/2/2001	955	200	10	5.14	0.8	71	22	20000	4	200	190	210
37	4	11/2/2001	1545	200	5	2.57	0.8	77	25	9500	4	200	160	240
38	4	11/8/2001	1820	360	0	0.00	1	64	18	8000	6	Random	Random	Random
39	4	11/14/2001	1945	360	0	0.00	0	52	11	40000	4	Random	Random	Random
40	4	12/2/2001	1940						-18		4	0	350	10
41	5	11/10/2001	900	360	0	0.00	0.2	46	8	4000	4	Random	Random	Random

Table 4
Odor Occurrence Vector Program
Test/Prediction

Nashville - Dry Creek

					Source Range			Receptor Range								
Event	**Receptor**	**Date**	**Time**	**Avg**	**Min**	**Max**	**Avg**	**Min**	**Max**	**Test1**	**Test 2**	**Validation**	**Vector**	**Potential Source**	**Dilutions**	**Potential Source**
1	1	10/10/01	630	Random	Random	Random	337	329	353	Maybe	Maybe	Valid	Random			
2	1	10/11/01	635	Random	Random	Random	337	329	353	Maybe	Maybe	Valid	Random			
3	1	10/11/01	1745	140	100	180	337	329	353	No	No	Not Valid	-			
4	1	10/17/01	1745	10	330	50	337	329	353	No	No	Not Valid	-			
5	1	10/18/01	1900	170	130	210	337	329	353	No	No	Not Valid	-			
6	1	10/19/01	700	Random	Random	Random	337	329	353	Maybe	Maybe	Valid	Random			
7	1	10/20/01	645	Random	Random	Random	337	329	353	Maybe	Maybe	Valid	Random			
8	1	10/23/01	1730	Random	Random	Random	337	329	353	Maybe	Maybe	Valid	Random			
9	1	10/24/01	645	210	170	250	337	329	353	No	No	Not Valid	-			
10	1	10/25/01	645	Random	Random	Random	337	329	353	Maybe	Maybe	Valid	Random			
11	1	10/26/01	630	Random	Random	Random	337	329	353	Maybe	Maybe	Valid	Random			
12	1	10/27/01	1800	360	320	680	337	329	353	No	Yes	Valid	360	EQ Basin	1680	Influent Channel - HW
13	1	10/28/01	1750	50	10	90	337	329	353	No	No	Not Valid	-			
14	1	10/29/01	645	Random	Random	Random	337	329	353	Maybe	Maybe	Valid	Random			
15	1	10/30/01	1645	Random	Random	Random	337	329	353	Maybe	Maybe	Valid	Random			
16	1	10/31/01	1730	170	130	210	337	329	353	No	No	Not Valid	-			
17	1	11/01/01	645	Random	Random	Random	337	329	353	Maybe	Maybe	Valid	Random			
18	1	11/02/01	1715	Random	Random	Random	337	329	353	Maybe	Maybe	Valid	Random			
19	1	11/04/01	2000	350	310	670	337	329	353	Yes	Yes	Valid	350	EQ Basin	1680	Aeration Basin 2-1 East
20	1	11/08/01	2000	360	320	680	337	329	353	No	Yes	Valid	360	EQ Basin	1680	Influent Channel - HW
21	1	11/14/01	1800	50	10	90	337	329	353	No	No	Not Valid	-			
22	1	11/21/01	1745	190	150	230	337	329	353	No	No	Not Valid	-			
23	1	11/22/01	1200	200	160	240	337	329	353	No	No	Not Valid	-			
24	1	11/22/01	2000	Random	Random	Random	337	329	353	Maybe	Maybe	Valid	Random			
25	2	10/10/01	645	Random	Random	Random	264	251	290	Maybe	Maybe	Valid	Random			
26	2	10/10/01	730	Random	Random	Random	264	251	290	Maybe	Maybe	Valid	Random			
27	2	10/11/01	645	Random	Random	Random	264	251	290	Maybe	Maybe	Valid	Random			
28	2	10/11/01	1730	Random	Random	Random	264	251	290	Maybe	Maybe	Valid	Random			
29	2	10/17/01	645	Random	Random	Random	264	251	290	Maybe	Maybe	Valid	Random			
30	3	10/17/01	905	300	260	340	190	154	209	No	No	Not Valid	-			
31	3	10/29/01	1800	160	120	200	190	154	209	Yes	Yes	Valid	160	EQ Basin	1680	Pri. Clarifier #7 Eff.
32	3	10/31/01	730	Random	Random	Random	190	154	209	Maybe	Maybe	Valid	Random			
33	4	10/29/01	1015	170	130	210	26	19	32	No	No	Not Valid	-			
34	4	10/31/01	2000	180	140	220	26	19	32	No	No	Not Valid	-			
35	4	11/01/01	1000	190	180	200	26	19	32	No	No	Not Valid	-			
36	4	11/02/01	955	200	190	210	26	19	32	No	No	Not Valid	-			
37	4	11/02/01	1545	200	160	240	26	19	32	No	No	Not Valid	-			
38	4	11/08/01	1820	Random	Random	Random	26	19	32	Maybe	Maybe	Valid	Random			
39	4	11/14/01	1945	Random	Random	Random	26	19	32	Maybe	Maybe	Valid	Random			
40	4	12/02/01	1940	0	350	10	26	19	32	No	No	Not Valid	-			
41	5	11/10/01	900	Random	Random	Random	181	173	186	Maybe	Maybe	Valid	Random			

Scrubber O&M Costs

Scrubber Design
by
Huber Environmental, Inc.

Facility Information -		Nashville - Dry Creek						
Location		Alternative 1						
Concentration		8						
Run Date -		4/29/2003						

Input Data

Selection of Parameters		(Use y for true, n for false)		L'	G'	HTU/3.5	HTU/2
NH_3	*n*	*Acid Scrubber Not Required*		*1024*	*492*	7	6
Mercapt*	*n*	*No Alkaline Scrubbing Required*		*5004*	*500*	32.2	*28*
H_2S	*y*	*Alkaline Scrubbing Will Be Required*		*1331*	*1229*	22	*19.4*

Recirculation Rates

Diameter	**GPM**
2	20
3	46
4	82
5	126
6	185
7	250
8	326
9	415
10	510
11	620
12	735

Safety Factor (%)		*20%*	**Oxidation**	
Stages	**(Acid)**		**None**	
Stages	**(Alkaline)**	*1*	**Partial**	
	Total	*1*	**Full**	**y**

Parameter Data

Parameter	Mole Weight	I - Conc (Avg)	I - Conc (Peak)	O - Conc (Avg)	O - Conc (Peak)	% Rem (Avg)	% Rem (Peak)
H_2S	*34*	*8*	*20*	*0.04*	*0.1*	*99.50%*	*99.50%*
Mercapt*	*62*					*0.00%*	*0.00%*
NH_3	*17*					*0.00%*	*0.00%*

* Add Molecular Weight

Inlet Air Data

ACFM	Temp (F)	Air Density	CO_2	CO_2 Corr.	External Loss	Loss/Stage
4800	*68*	*0.075*			*6*	*6*

Scrubbing Chemicals Data

Chemical	Mol. Wt	Sp. Gr	Conc. Factor	H_2S	Mercap	NH_3	Storage
A - NaOH	*40*	*10*	*25%*	*2.4*	*0.65*		*30*
B - NaOCl	*74.4*	*7.83*	*12.5%*	*8.9*	*3.6*		*30*
C - H_2SO_4	*98*	*8*	*93%*			*2.88*	*30*

Cost Data

	Electrical	A	B	C	Labor
	$0.035	*$0.45*	*$0.73*	*$1.00*	*$1.00*

Scrubber Design

Acid Stage		**Skip This Section**							
Gas #/Hr	Velocity	Tank Dia	Adj. Tk Dia.	Adj. Vel	Tank Area	NOG(Req)	Packing Size	Flow Rate	L'
21600		*0.00*		*0.00*	*0.00*	*0.00*			*0*
Des. Flow	L	L(Cor)	G'	Des Air	G	G(Cor)	HTU	HTU(Cor)	Z(Req)
0.00	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*	*0.000*	*0.00*
Z(Fin)	Depth/Stage	Set Depth	Z (Tot)	NOG(Fin)	NOG(1)	NOG(2)			
0.00	*0.00*		*0*	*0.00*	0.00	0.00			

Scrubber Design
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Alkaline Stage(s)										
Mercaptan		**Skip This Section and Go To H2S**								
Gas #/Hr	Velocity	Tank Dia	Adj. Tk Dia.	Final Tank Dia.	Final Velocity	Tank Area	NOG(Req)	Packing Size	Flow Rate	
21600.0		*0.00*		*4.0*	*0.00*	*12.56*	*0.00*			
L'	Des. Flow	L	L(Cor)	G'	Des Air	G	G(Cor)	HTU	HTU(Cor)	
0	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*	
Z(Req)	Z(Fin)	Depth/Stage	Set Depth	Z(Prelim)	Z(Final)	NOG(Fin)	NOG(1)	NOG(2)		
0.00	*0.00*	*0.00*		*0*	*0*	*0.00*	*0.00*	*0.00*		
H_2S										
Gas #/Hr	Velocity	Tank Dia	Adj. Tk Dia.	Final Tank Dia.	Final Velocity	Tank Area	NOG(Req)	Packing Size	Flow Rate	
21600.00	*500.00*	*3.50*	*4.00*	*4.00*	*382.17*	*12.56*	*5.30*	*3.50*	*82.0*	
Des. Flow	L	L(Cor)	G'	Des Air	G	G(Cor)	HTU	HTU(Cor)	Z(Req)	
33.41	*3266.94*	*0.74*	*1229.00*	*3430.28*	*1719.75*	*1.07*	*1.83*	*1.45*	*7.70*	
L'	Z(Fin)	Depth/Stage	Set Depth	Z(Prelim)	Z(Final)	NOG(Fin)	NOG(1)	NOG(2)		
1331.00	*9.24*	*9.24*	*10.00*	*10*	*10*	*6.88*	*6.88*	*0.00*		
Final										
Acid										
Tank Dia	Tank Area	Velocity	*Z*	Flow Rate	*Stages*					
0.00	*0.00*	*0.00*	*0*	*0*	*0*					
Alkaline										
Tank Dia	Tank Area	Velocity	*Z*	Flow Rate	Stages					
4.00	*12.56*	*382.17*	*10*	*82*	*1*					
NH3										
					Average					
		Stage 1			Stage 2				Total	
Inlet	Outlet	Lbs/Hr	% Removal	Inlet	Outlet	Lbs/Hr	% Removal	Lbs/Hr	% Removal	% Removal (Corr.)
0.00	*0.00*	*0.00*	*0.00%*	*0.00*	*0.00*	*0.00*	*0.00%*	*0.00*	*0.00%*	*0.00%*
					Peak					
		Stage 1			Stage 2				Total	
Inlet	Outlet	Lbs/Hr	% Removal	Inlet	Outlet	Lbs/Hr	% Removal	Lbs/Hr	% Removal	% Removal (Corr.)
0.00	*0.00*	*0.00*	*0.00%*	*0.00*	*0.00*	*0.00*	*0.00%*	*0.00*	*0.00%*	*0.00%*
H_2S										
					Average					
		Stage 1			Stage 2				Total	
Inlet	Outlet	Lbs/Hr	% Removal	Inlet	Outlet	Lbs/Hr	% Removal	Lbs/Hr	% Removal	% Removal (Corr.)
8.00	*0.01*	*0.20*	*99.90%*	*0.00*	*0.00*	*0.00*	*0.00%*	*0.20*	*99.90%*	*99.90%*
					Peak					
		Stage 1			Stage 2				Total	
Inlet	Outlet	Lbs/Hr	% Removal	Inlet	Outlet	Lbs/Hr	% Removal	Lbs/Hr	% Removal	% Removal (Corr.)
20.00	*0.02*	*0.51*	*99.90%*	*0.00*	*0.00*	*0.00*	*0.00%*	*0.51*	*99.90%*	*99.90%*
Mercaptan										
					Average					
		Stage 1			Stage 2				Total	
Inlet	Outlet	Lbs/Hr	% Removal	Inlet	Outlet	Lbs/Hr	% Removal	Lbs/Hr	% Removal	% Removal (Corr.)
0.00	*0.00*	*0.00*	0.00%	*0.00*	*0.00*	*0.00*	*0.00%*	*0.00*	*0.00%*	*0.00%*
					Peak					
		Stage 1			Stage 2				Total	
Inlet	Outlet	Lbs/Hr	% Removal	Inlet	Outlet	Lbs/Hr	% Removal	Lbs/Hr	% Removal	% Removal (Corr.)
0.00	*0.00*	*0.00*	0.00%	*0.00*	*0.00*	*0.00*	0.00%	*0.00*	*0.00%*	*0.00%*

Scrubber Design
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					Output Data				
Chemical Usage									
Acid									
			Average						
	Stage 1		Stage 2		Total				
	Lbs/Hr	Gal/Hr	Lbs/Hr	Gal/Hr	Gal/Hr	Gal/Day			
H_2SO_4	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*			
			Peak						
	Stage 1		Stage 2		Total				
	Lbs/Hr	Gal/Hr	Lbs/Hr	Gal/Hr	Gal/Hr	Gal/Day			
H_2SO_4	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*			
Alkaline									
				Average					
	Stage 1		Stage 2		Total				
	Lbs/Hr	Gal/Hr	Lbs/Hr	Gal/Hr	Gal/Hr	Gal/Day			
NaOH	*0.49*	*0.19*	*0.00*	*0.00*	*0.19*	*4.68*			
NaOCl	*1.81*	*1.85*	*0.00*	*0.00*	*1.85*	*44.33*			
				Peak					
	Stage 1		Stage 2		Total				
	Lbs/Hr	Gal/Hr	Lbs/Hr	Gal/Hr	Gal/Hr	Gal/Day			
NaOH	*1.22*	*0.49*	*0.00*	*0.00*	*0.49*	*11.70*			
NaOCl	*4.52*	*4.62*	*0.00*	*0.00*	*4.62*	*110.82*			
Metering Pumps									
	Stage 1		Stage 2						
	Gals/Hr	GPM	Gals/Hr	GPM					
NaOH	*0.49*	*0.01*	*0.00*	*0.00*					
NaOCl	*4.62*	*0.08*	*0.00*	*0.00*					
H_2SO_4	*0.00*	*0.00*	*0.00*	*0.00*					
Chemical Storage Tanks				**Blowdown Rate**					
				Amount	Solubility	GPM			
NaOH	*140*		NH_4SO_4	*0.00*	*71.00*	*0.00*			
NaOCl	*1330*		NaCl	*1.40*	*36.00*	*0.02*			
H_2SO_4	*0*		Na_2SO_4	*0.85*	*19.00*	*0.03*			
			Evaporation	*10.00*		*0.80*			
			Total			*0.85*			
Operating Costs									
Electrical									
	Fan		Recirculation Pumps				Chemical Metering Pumps		
		Acid		Alkaline		Acid		Alkaline	
		Stage 1	Stage 2	Stage 1	Stage 2	Stage 1	Stage 2	Stage 1	Stage 2
HP	*6.80*	*0.00*	*0.00*	*2.47*	*0.00*	*0*	*0.00*	*0.50*	*0.00*
Adjusted HP	*10.00*			*5.00*				*0.50*	
Kw-Hrs	*179.04*	*0.00*	*0.00*	*89.52*	*0.00*	*0.00*	*0.00*	*8.95*	*0.00*
Cost	*$6*	*$0*	*$0*	*$3*	*$0*	*$0*	*$0*	*$0*	*$0*
Chemicals									
	Acid			Alkaline					
	Stage 1	Stage 2	Stage 1		Stage 2				
			NaOH	NaOCl	NaOH	NaOCl			
lbs/hr	*0.00*	*0.00*	*0.49*	*1.81*	*0.00*	*0.00*			
Cost/day	*$0*	*$0*	*$5*	*$32*	*$0.00*	*$0.00*			
Annual Cost									
Labor	*$4,800*								
Electrical	*$3,545*								
Chemicals	*$13,491*								
Total	*$21,836*								

Scrubber Design
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Facility Information -		Nashville - Dry Creek						
Location		Alternative #3 Revised						
Concentration		5						
Run Date -		4/29/2003						

Input Data

Selection of Parameters		(Use y for true, n for false)		**L'**	**G'**	**HTU/3.5**	**HTU/2**
NH_3	*n*	*Acid Scrubber Not Required*		*1024*	*492*	7	*6*
Mercapt*	*n*	*No Alkaline Scrubbing Required*		*5004*	*500*	32.2	*28*
H_2S	*y*	*Alkaline Scrubbing Will Be Required*		*1331*	*1229*	22	*19.4*

Recirculation Rates

Diameter	**GPM**
2	20
3	46
4	82
5	126
6	185
7	250
8	326
9	415
10	510
11	620
12	735

Safety Factor (%)		*20%*	**Oxidation**	
Stages	**(Acid)**		**None**	
Stages	**(Alkaline)**	*1*	**Partial**	
	Total	*1*	**Full**	**y**

Parameter Data

Parameter	Mole Weight	I - Conc (Avg)	I - Conc (Peak)	O - Conc (Avg)	O - Conc (Peak)	% Rem (Avg)	% Rem (Peak)
H_2S	*34*	*5*	*10*	*0.025*	*0.05*	*99.50%*	*99.50%*
Mercapt*	*62*					*0.00%*	*0.00%*
NH_3	*17*					*0.00%*	*0.00%*

* Add Molecular Weigh

Inlet Air Data

ACFM	Temp (F)	Air Density	CO_2	CO_2 Corr.	External Loss	Loss/Stage
11000	*68*	*0.075*			*6*	*6*

Scrubbing Chemicals Data

Chemical	Mol. Wt	Sp. Gr	Conc. Factor	H_2S	Mercap	NH_3	Storage
A - NaOH	*40*	*10*	*25%*	*2.4*	*0.65*		*30*
B - NaOCl	*74.4*	*7.83*	*12.5%*	*8.9*	*3.6*		*30*
C - H_2SO_4	*98*	*8*	*93%*			*2.88*	*30*

Cost Data

	Electrical	A	B	C	Labor
	$0.035	*$0.45*	*$0.73*	*$1.00*	*$1.00*

Scrubber Design

Acid Stage		**Skip This Section**							
Gas #/Hr	Velocity	Tank Dia	Adj. Tk Dia.	Adj. Vel	Tank Area	NOG(Req)	Packing Size	Flow Rate	L'
49500		*0.00*		*0.00*	*0.00*	*0.00*			*0*
Des. Flow	L	L(Cor)	G'	Des Air	G	G(Cor)	HTU	HTU(Cor)	Z(Req)
0.00	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*	*0.000*	*0.00*
Z(Fin)	Depth/Stage	Set Depth	Z (Tot)	NOG(Fin)	NOG(1)	NOG(2)			
0.00	*0.00*		*0*	*0.00*	0.00	0.00			

Scrubber Design
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Alkaline Stage(s)												
Mercaptan		**Skip This Section and Go To H2S**										
Gas #/Hr	Velocity	Tank Dia	Adj. Tk Dia.	Final Tank Dia.	Final Velocity	Tank Area	NOG(Req)	Packing Size	Flow Rate			
49500.0		*0.00*		*5.0*	*0.00*	*19.63*	*0.00*					
L'	Des. Flow	L	L(Cor)	G'	Des Air	G	G(Cor)	HTU	HTU(Cor)			
0	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*			
Z(Req)	Z(Fin)	Depth/Stage	Set Depth	Z(Prelim)	Z(Final)	NOG(Fin)	NOG(1)	NOG(2)				
0.00	*0.00*	*0.00*		*0*	*0*	*0.00*	*0.00*	*0.00*				
H_2S												
Gas #/Hr	Velocity	Tank Dia	Adj. Tk Dia.	Final Tank Dia.	Final Velocity	Tank Area	NOG(Req)	Packing Size	Flow Rate			
49500.00	*500.00*	*5.29*	*5.00*	*5.00*	*560.51*	*19.63*	*5.30*	*3.50*	*126.0*			
Des. Flow	L	L(Cor)	G'	Des Air	G	G(Cor)	HTU	HTU(Cor)	Z(Req)			
52.20	*3212.76*	*0.75*	*1229.00*	*5359.81*	*2522.29*	*1.15*	*1.83*	*1.58*	*8.36*			
L'	Z(Fin)	Depth/Stage	Set Depth	Z(Prelim)	Z(Final)	NOG(Fin)	NOG(1)	NOG(2)				
1331.00	*10.03*	*10.03*	*10.00*	*10*	*10*	*6.34*	*6.34*	*0.00*				
Final												
Acid												
Tank Dia	Tank Area	Velocity	Z	Flow Rate	*Stages*							
0.00	*0.00*	*0.00*	*0*	*0*	*0*							
Alkaline												
Tank Dia	Tank Area	Velocity	Z	Flow Rate	Stages							
5.00	*19.63*	*560.51*	*10*	*126*	*1*							
NH3												
					Average							
		Stage 1			Stage 2				Total			
Inlet	Outlet	Lbs/Hr	% Removal	Inlet	Outlet	Lbs/Hr	% Removal	Lbs/Hr	% Removal	% Removal (Corr.)		
0.00	*0.00*	*0.00*	*0.00%*	*0.00*	*0.00*	*0.00*	*0.00%*	*0.00*	*0.00%*	*0.00%*		
					Peak							
		Stage 1			Stage 2				Total			
Inlet	Outlet	Lbs/Hr	% Removal	Inlet	Outlet	Lbs/Hr	% Removal	Lbs/Hr	% Removal	% Removal (Corr.)		
0.00	*0.00*	*0.00*	*0.00%*	*0.00*	*0.00*	*0.00*	*0.00%*	*0.00*	*0.00%*	*0.00%*		
H_2S												
					Average							
		Stage 1			Stage 2				Total			
Inlet	Outlet	Lbs/Hr	% Removal	Inlet	Outlet	Lbs/Hr	% Removal	Lbs/Hr	% Removal	% Removal (Corr.)		
5.00	*0.01*	*0.29*	*99.82%*	*0.00*	*0.00*	*0.00*	*0.00%*	*0.29*	*99.82%*	*99.62%*		
					Peak							
		Stage 1			Stage 2				Total			
Inlet	Outlet	Lbs/Hr	% Removal	Inlet	Outlet	Lbs/Hr	% Removal	Lbs/Hr	% Removal	% Removal (Corr.)		
10.00	*0.02*	*0.58*	*99.82%*	*0.00*	*0.00*	*0.00*	*0.00%*	*0.58*	*99.82%*	*99.62%*		
Mercaptan												
					Average							
		Stage 1			Stage 2				Total			
Inlet	Outlet	Lbs/Hr	% Removal	Inlet	Outlet	Lbs/Hr	% Removal	Lbs/Hr	% Removal	% Removal (Corr.)		
0.00	*0.00*	*0.00*	0.00%	*0.00*	*0.00*	*0.00*	*0.00%*	*0.00*	*0.00%*	*0.00%*		
					Peak							
		Stage 1			Stage 2				Total			
Inlet	Outlet	Lbs/Hr	% Removal	Inlet	Outlet	Lbs/Hr	% Removal	Lbs/Hr	% Removal	% Removal (Corr.)		
0.00	*0.00*	*0.00*	0.00%	*0.00*	*0.00*	*0.00*	0.00%	*0.00*	*0.00%*	*0.00%*		

Scrubber Design
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Output Data									
Chemical Usage									
Acid									
	Average								
	Stage 1		Stage 2		Total				
	Lbs/Hr	Gal/Hr	Lbs/Hr	Gal/Hr	Gal/Hr	Gal/Day			
H_2SO_4	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*			
	Peak								
	Stage 1		Stage 2		Total				
	Lbs/Hr	Gal/Hr	Lbs/Hr	Gal/Hr	Gal/Hr	Gal/Day			
H_2SO_4	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*			
Alkaline									
	Average								
	Stage 1		Stage 2		Total				
	Lbs/Hr	Gal/Hr	Lbs/Hr	Gal/Hr	Gal/Hr	Gal/Day			
NaOH	*0.70*	*0.28*	*0.00*	*0.00*	*0.28*	*6.70*			
NaOCl	*2.59*	*2.64*	*0.00*	*0.00*	*2.64*	*63.44*			
	Peak								
	Stage 1		Stage 2		Total				
	Lbs/Hr	Gal/Hr	Lbs/Hr	Gal/Hr	Gal/Hr	Gal/Day			
NaOH	*1.40*	*0.56*	*0.00*	*0.00*	*0.56*	*13.40*			
NaOCl	*5.17*	*5.29*	*0.00*	*0.00*	*5.29*	*126.89*			
Metering Pumps									
	Stage 1		Stage 2						
	Gals/Hr	GPM	Gals/Hr	GPM					
NaOH	*0.56*	*0.01*	*0.00*	*0.00*					
NaOCl	*5.29*	*0.09*	*0.00*	*0.00*					
H_2SO_4	*0.00*	*0.00*	*0.00*	*0.00*					
Chemical Storage Tanks			**Blowdown Rate**						
				Amount	Solubility	GPM			
NaOH	*201*		NH_4SO_4	*0.00*	*71.00*	*0.00*			
NaOCl	*1903*		NaCl	*2.01*	*36.00*	*0.03*			
H_2SO_4	*0*		Na_2SO_4	*1.22*	*19.00*	*0.04*			
			Evaporation	*10.00*		*1.83*			
			Total			*1.91*			
Operating Costs									
Electrical									
	Fan	Recirculation Pumps				Chemical Metering Pumps			
		Acid		Alkaline		Acid		Alkaline	
		Stage 1	Stage 2	Stage 1	Stage 2	Stage 1	Stage 2	Stage 1	Stage 2
HP	*15.58*	*0.00*	*0.00*	*3.79*	*0.00*	*0*	*0.00*	*0.50*	*0.00*
Adjusted HP	*20.00*			*5.00*				*0.50*	
Kw-Hrs	*358.08*	*0.00*	*0.00*	*89.52*	*0.00*	*0.00*	*0.00*	*8.95*	*0.00*
Cost	*$13*	*$0*	*$0*	*$3*	*$0*	*$0*	*$0*	*$0*	*$0*
Chemicals									
	Acid		Alkaline						
	Stage 1	Stage 2	Stage 1		Stage 2				
			NaOH	NaOCl	NaOH	NaOCl			
lbs/hr	*0.00*	*0.00*	*0.70*	*2.59*	*0.00*	*0.00*			
Cost/day	*$0*	*$0*	*$8*	*$45*	*$0.00*	*$0.00*			
Annual Cost									
Labor	*$11,000*								
Electrical	*$5,832*								
Chemicals	*$19,308*								
Total	*$36,141*								

Scrubber Design
by
Huber Environmental, Inc.

Facility Information -		Nashville - Dry Creek	
Location		Alternative #5 (Revised)	
Concentration		22	
Run Date -		4/29/2003	

Input Data

Selection of Parameters		(Use y for true, n for false)	**L'**	**G'**	**HTU/3.5**	**HTU/2**
NH_3	*n*	*Acid Scrubber Not Required*	*1024*	*492*	7	*6*
Mercapt*	*n*	*No Alkaline Scrubbing Required*	*5004*	*500*	32.2	*28*
H_2S	*y*	*Alkaline Scrubbing Will Be Required*	*1331*	*1229*	22	*19.4*

Recirculation Rates

Diameter	**GPM**
2	20
3	46
4	82
5	126
6	185
7	250
8	326
9	415
10	510
11	620
12	735

Safety Factor (%)		*20%*	**Oxidation**	
Stages	**(Acid)**		**None**	
Stages	**(Alkaline)**	*2*	**Partial**	
	Total	*2*	**Full**	**y**

Parameter Data

Parameter	Mole Weight	I - Conc (Avg)	I - Conc (Peak)	O - Conc (Avg)	O - Conc (Peak)	% Rem (Avg)	% Rem (Peak)
H_2S	*34*	*22*	*44*	*0.05*	*0.1*	*99.77%*	*99.77%*
Mercapt*	*62*					*0.00%*	*0.00%*
NH_3	*17*					*0.00%*	*0.00%*

* Add Molecular Weigh

Inlet Air Data

ACFM	Temp (F)	Air Density	CO_2	CO_2 Corr.	External Loss	Loss/Stage
35000	*68*	*0.075*			*6*	*6*

Scrubbing Chemicals Data

Chemical	Mol. Wt	Sp. Gr	Conc. Factor	H_2S	Mercap	NH_3	Storage
A - NaOH	*40*	*10*	*25%*	*2.4*	*0.65*		*30*
B - NaOCl	*74.4*	*7.83*	*12.5%*	*8.9*	*3.6*		*30*
C - H_2SO_4	*98*	*8*	*93%*			*2.88*	*30*

Cost Data

	Electrical	A	B	C	Labor
	$0.035	*$0.45*	*$0.73*	*$1.00*	*$1.00*

Scrubber Design

Acid Stage		**Skip This Section**							
Gas #/Hr	Velocity	Tank Dia	Adj. Tk Dia.	Adj. Vel	Tank Area	NOG(Req)	Packing Size	Flow Rate	L'
157500		*0.00*		*0.00*	*0.00*	*0.00*			*0*
Des. Flow	L	L(Cor)	G'	Des Air	G	G(Cor)	HTU	HTU(Cor)	Z(Req)
0.00	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*	*0.000*	*0.00*
Z(Fin)	Depth/Stage	Set Depth	Z (Tot)	NOG(Fin)	NOG(1)	NOG(2)			
0.00	*0.00*		*0*	*0.00*	0.00	0.00			

Scrubber Design
by
Huber Environmental, Inc.

Alkaline Stage(s)												
Mercaptan		**Skip This Section and Go To H2S**										
Gas #/Hr	Velocity	Tank Dia	Adj. Tk Dia.	Final Tank Dia.	Final Velocity	Tank Area	NOG(Req)	Packing Size	Flow Rate			
157500.0		*0.00*		*10.0*	*0.00*	*78.50*	*0.00*					
L'	Des. Flow	L	L(Cor)	G'	Des Air	G	G(Cor)	HTU	HTU(Cor)			
0	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*			
Z(Req)	Z(Fin)	Depth/Stage	Set Depth	Z(Prelim)	Z(Final)	NOG(Fin)	NOG(1)	NOG(2)				
0.00	*0.00*	*0.00*		*0*	*0*	*0.00*	*0.00*	*0.00*				
H_2S												
Gas #/Hr	Velocity	Tank Dia	Adj. Tk Dia.	Final Tank Dia.	Final Velocity	Tank Area	NOG(Req)	Packing Size	Flow Rate			
157500.00	*500.00*	*9.44*	*10.00*	*10.00*	*445.86*	*78.50*	*6.09*	*3.50*	*510.0*			
Des. Flow	L	L(Cor)	G'	Des Air	G	G(Cor)	HTU	HTU(Cor)	Z(Req)			
208.80	*3251.01*	*0.74*	*1229.00*	*21439.22*	*2006.37*	*1.10*	*1.83*	*1.50*	*9.13*			
L'	Z(Fin)	Depth/Stage	Set Depth	Z(Prelim)	Z(Final)	NOG(Fin)	NOG(1)	NOG(2)				
1331.00	*10.96*	*5.48*	*10.00*	*20*	*20*	*13.33*	*6.66*	*6.66*				
Final												
Acid												
Tank Dia	Tank Area	Velocity	*Z*	Flow Rate	*Stages*							
0.00	*0.00*	*0.00*	*0*	*0*	*0*							
Alkaline												
Tank Dia	Tank Area	Velocity	*Z*	Flow Rate	Stages							
10.00	*78.50*	*445.86*	*20*	*510*	*2*							
NH3												
					Average							
		Stage 1			Stage 2				Total			
Inlet	Outlet	Lbs/Hr	% Removal	Inlet	Outlet	Lbs/Hr	% Removal	Lbs/Hr	% Removal	% Removal (Corr.)		
0.00	*0.00*	*0.00*	*0.00%*	*0.00*	*0.00*	*0.00*	*0.00%*	*0.00*	*0.00%*	*0.00%*		
					Peak							
		Stage 1			Stage 2				Total			
Inlet	Outlet	Lbs/Hr	% Removal	Inlet	Outlet	Lbs/Hr	% Removal	Lbs/Hr	% Removal	% Removal (Corr.)		
0.00	*0.00*	*0.00*	*0.00%*	*0.00*	*0.00*	*0.00*	*0.00%*	*0.00*	*0.00%*	*0.00%*		
H_2S												
					Average							
		Stage 1			Stage 2				Total			
Inlet	Outlet	Lbs/Hr	% Removal	Inlet	Outlet	Lbs/Hr	% Removal	Lbs/Hr	% Removal	% Removal (Corr.)		
22.00	*0.03*	*4.07*	*99.87%*	*0.03*	*0.00*	*0.00*	*99.87%*	*4.07*	*100.00%*	*100.00%*		
					Peak							
		Stage 1			Stage 2				Total			
Inlet	Outlet	Lbs/Hr	% Removal	Inlet	Outlet	Lbs/Hr	% Removal	Lbs/Hr	% Removal	% Removal (Corr.)		
44.00	*0.06*	*8.14*	*99.87%*	*0.06*	*0.00*	*0.01*	*99.87%*	*8.15*	*100.00%*	*100.00%*		
Mercaptan												
					Average							
		Stage 1			Stage 2				Total			
Inlet	Outlet	Lbs/Hr	% Removal	Inlet	Outlet	Lbs/Hr	% Removal	Lbs/Hr	% Removal	% Removal (Corr.)		
0.00	*0.00*	*0.00*	0.00%	*0.00*	*0.00*	*0.00*	*0.00%*	*0.00*	*0.00%*	*0.00%*		
					Peak							
		Stage 1			Stage 2				Total			
Inlet	Outlet	Lbs/Hr	% Removal	Inlet	Outlet	Lbs/Hr	% Removal	Lbs/Hr	% Removal	% Removal (Corr.)		
0.00	*0.00*	*0.00*	0.00%	*0.00*	*0.00*	*0.00*	0.00%	*0.00*	*0.00%*	*0.00%*		

Output Data

Chemical Usage

Acid

	Average					
	Stage 1		Stage 2		Total	
	Lbs/Hr	Gal/Hr	Lbs/Hr	Gal/Hr	Gal/Hr	Gal/Day
H_2SO_4	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*

	Peak					
	Stage 1		Stage 2		Total	
	Lbs/Hr	Gal/Hr	Lbs/Hr	Gal/Hr	Gal/Hr	Gal/Day
H_2SO_4	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*

Alkaline

	Average					
	Stage 1		Stage 2		Total	
	Lbs/Hr	Gal/Hr	Lbs/Hr	Gal/Hr	Gal/Hr	Gal/Day
NaOH	*9.77*	*3.91*	*0.00*	*0.00*	*3.91*	*93.82*
NaOCl	*36.24*	*37.03*	*0.00*	*0.00*	*37.03*	*888.65*

	Peak					
	Stage 1		Stage 2		Total	
	Lbs/Hr	Gal/Hr	Lbs/Hr	Gal/Hr	Gal/Hr	Gal/Day
NaOH	*19.55*	*7.82*	*0.02*	*0.01*	*7.83*	*187.88*
NaOCl	*72.48*	*74.05*	*0.09*	*0.09*	*74.15*	*1779.58*

Metering Pumps

	Stage 1		Stage 2	
	Gals/Hr	GPM	Gals/Hr	GPM
NaOH	*7.82*	*0.13*	*0.01*	*0.00*
NaOCl	*74.05*	*1.23*	*0.09*	*0.00*
H_2SO_4	*0.00*	*0.00*	*0.00*	*0.00*

Chemical Storage Tanks

			Blowdown Rate		
			Amount	Solubility	GPM
NaOH	*2815*	NH_4SO_4	*0.00*	*71.00*	*0.00*
NaOCl	*26660*	NaCl	*28.10*	*36.00*	*0.47*
H_2SO_4	*0*	Na_2SO_4	*17.10*	*19.00*	*0.54*
		Evaporation	*10.00*		*5.83*
		Total			*6.84*

Operating Costs

Electrical

	Fan	Recirculation Pumps				Chemical Metering Pumps			
		Acid		Alkaline		Acid		Alkaline	
		Stage 1	Stage 2	Stage 1	Stage 2	Stage 1	Stage 2	Stage 1	Stage 2
HP	*74.34*	*0.00*	*0.00*	*15.33*	*15.33*	*0*	*0.00*	*0.50*	*0.50*
Adjusted HP	*75.00*			*20.00*				*0.50*	
Kw-Hrs	*1342.80*	*0.00*	*0.00*	*358.08*	*0.00*	*0.00*	*0.00*	*8.95*	*0.00*
Cost	*$47*	*$0*	*$0*	*$13*	*$0*	*$0*	*$0*	*$0*	*$0*

Chemicals

	Acid		Alkaline			
	Stage 1	Stage 2	Stage 1		Stage 2	
			NaOH	NaOCl	NaOH	NaOCl
lbs/hr	*0.00*	*0.00*	*9.77*	*36.24*	*0.00*	*0.00*
Cost/day	*$0*	*$0*	*$106*	*$635*	*$0.00*	*$0.00*

Annual Cost

Labor	*$35,000*
Electrical	*$21,843*
Chemicals	*$270,445*
Total	*$327,288*